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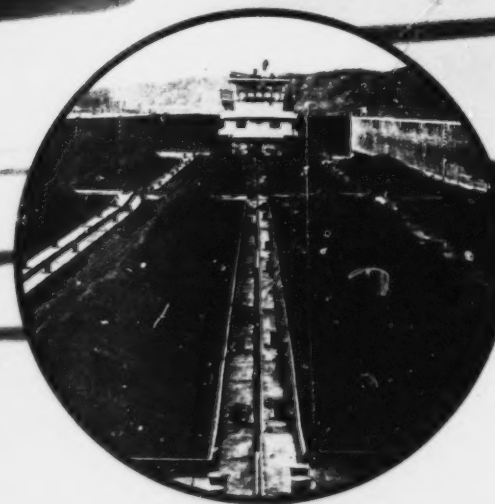
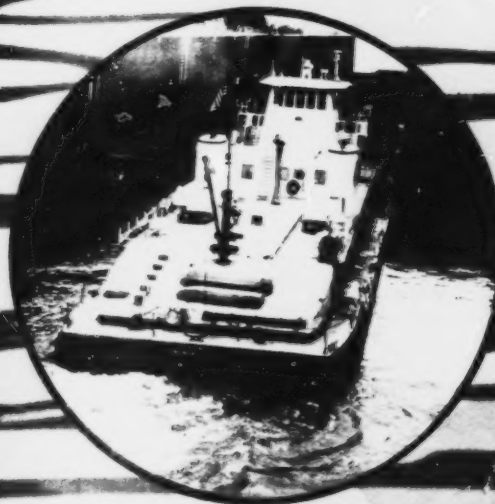
Projections Of Demand
For Waterborne
Transportation

Ohio River Basin
1980 - 2040

Volume 2

Methodology

U. S. Army Corps of Engineers
Ohio River Division
Cincinnati, Ohio



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(Continued from #20)

The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 2, Methodology, of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title
1	Study summary
2	Methodology
3	Group I: Coal and coke
4	Group II: Petroleum fuels
5	Group III: Crude Petrol.
6	Group IV: Aggregates
7	Group V: Grains
8	Group VI: Chemicals and chemical fertilizers
9	Group VII: Ores and Minerals
10	Group VIII: Iron ore, steel and iron
11	Group IX: Feed and food products, nec.
12	Group X: Wood and paper products
13	Group XI: Petroleum products, nec.
14	Group XII: Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII: Nonferrous, metals and alloys, nec.
16	Group XIV: Manufactured products, nec.
17	Group XV: Other, nec.

Additionally, an Executive Summary is available as a separate document.

METHODOLOGY

**PROJECTIONS OF DEMAND
FOR
WATERBORNE TRANSPORTATION
OHIO RIVER BASIN
1980, 1990, 2000, 2020, 2040**

Prepared for

**U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT**

Contract No. DACW69-78-C-0136

by

**Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.**

DECEMBER 1980

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River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2.
Methodology.--v.3. Commodity groups .

1. Shipping--Ohio River Basin. 2. Inland
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PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity

movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

<u>Subject Title</u>	<u>Number of Pages</u>	<u>Volume Number</u>
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.



**PROJECTIONS OF DEMAND FOR WATERBORNE
TRANSPORTATION
OHIO RIVER BASIN
1980, 1990, 2000, 2020, 2040**

Methodology

**Prepared for
U.S. Army Corps of Engineers
Huntington District
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November 1980

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I. INTRODUCTION

Work performed by RRNA to project the future demand for waterway transportation in the Ohio River Basin (ORB) required investigation and analyses of the production, consumption, and transportation characteristics of 15 commodity groups. The work consisted of two major tasks. First, the sizes and patterns of historical commodity demands were determined and analyzed. Second, projections of future commodity movements were developed for the period 1980 to 2040 (including intermediate years) based upon projected future demands for waterborne commodities both within and outside the ORB as well as the projected supplies of these commodities.

A general overview and explanation of the procedures used in this study are presented in this report. This Methodology Report summarizes the major assumptions of the study and highlights significant interrelationships among groups. The individual commodity group reports contain more detailed discussions of various data sources and assumptions that are unique to the commodity groups.

The Methodology Report also explains the procedures used to allocate projected waterway flows to origin-destination pairs. The Technical Appendix (Section VIII) to this report contains the computer programs and procedures which form the Flow Model.

The 15 commodity groups for which projections were made include:

Group	I:	Coal and coke
Group	II:	Petroleum fuels
Group	III:	Crude petroleum
Group	IV:	Aggregates
Group	V:	Grains
Group	VI:	Chemicals and chemical fertilizers

- Group VII: Ores and minerals
- Group VIII: Iron ore, steel and iron
- Group IX: Feed and food products, nec.
- Group X: Wood and paper products
- Group XI: Petroleum products, nec.
- Group XII: Rubber, plastic, nonmetallic mineral products, nec.
- Group XIII: Nonferrous metals and alloys, nec.
- Group XIV: Manufactured products, nec.
- Group XV: Others, nec.

In addition to the study summary, a report for each of these 15 commodity groups has been published.

A. Historical Production, Consumption, and Movements of Commodities

The initial step undertaken in the analysis was the identification of the relevant Ohio River System (ORS) hinterland for each group. The ORS hinterland was defined as U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) which are the ultimate origins and/or destinations of waterborne movements. For some of the commodity groups, their ORS hinterlands include entire BEAs. However, for most commodity groups, their ORS hinterland is composed of BEA segments (only certain counties within a BEA). The BEAs and BEA segments that comprise the ORS hinterlands of the commodity groups have been designated as Primary Study Areas (PSAs). The hinterland delineation is discussed more fully in Section II of this report.

For each of the 15 commodity groups, historical production and consumption, by PSA, were determined. The sources of historical production and consumption data include the Bureau of Mines, U.S. Department of the Interior; the Economic Research Service and Statistical Reporting Service, U.S. Department of Agriculture; the Bureau of Economic Analysis and the Bureau of the Census, U.S. Department of Commerce; the U.S. Department of Energy; the U.S. Department of Transportation; and state agencies, such as state geological surveys, crop reporting services, and state commerce and transportation departments. In addition, data were provided by various local government agencies, as well as educational and research institutions in the Ohio River Basin (ORB). Many industry associations and individual commodity producers also were contacted. The sources and procedures used to make production and consumption estimates are outlined in each of the commodity group reports. A general overview and explanation of procedures are contained in this report.

Historical commodity movements were estimated on the basis of waterborne and rail shipment data provided by the Corps of Engineers. Information regarding truck movements was inadequate to determine detailed historical truck shipments. However, estimates of net truck shipments (outbound less inbound shipments) were derived from commodity production and consumption estimates made for each PSA. Total net commodity shipments (production minus consumption), less outbound water and rail shipments, plus inbound water and rail shipments equals net truck shipments.

Estimates of historical commodity production, consumption and shipments were analyzed to determine factors affecting modal choice, and to identify past trends and probable future changes in trends. Explicit consideration was given to the opinions and expert judgments of government agency staff members, shippers and receivers, and professional researchers associated with education and research institutions in the ORB. During the course of this investigation, over 200 field interviews were conducted. In addition, approximately 400 telephone interviews were conducted.

B. Projections of Future Commodity Movements

Future production and consumption of commodity groups, by PSA, were projected for the years 1980, 1990, 2000, 2020 and 2040. These projections usually were based on existing national and regional projections developed by Federal agencies. Although these projections were derived from outside sources, these projections are reflective of the judgment of RRNA regarding the most probable future. These projections were disaggregated to PSA levels and adjusted on the basis of field research. A major aim of the projection methodology was to develop a set of projections for each commodity group that was consistent with all other commodity group projections. Thus, DOE projections were the basis of all energy-related commodities; the Bureau of Mines was the source of non-energy, nonferrous mineral and ore projections; the U.S. Department of Agriculture was the source of grain projections, as well as some components of chemical fertilizer and feed and food product projections; and projections of economic activity by industry estimated by the Bureau of Economic Analysis for OBERS Projections were used for the remaining commodities.

Projections of a commodity group, or of a commodity within a group, were often used as a basis for projecting other commodity groups. Thus, projections of iron and steel production were the basis for projections of metallurgical coal consumption and the

projections of lime used as flux in the production of steel. Specific sources and procedures used in the projections of the production and consumption of commodity groups and individual commodities are listed in the individual commodity group reports.

Projections of commodity shipments, receipts and modal splits were based on projections of production and consumption, by PSA, on 1976 traffic patterns and on past trends. Adjustments were made to reflect the judgments of industry experts and the stated intentions of individual firms. The 1976 waterborne traffic movements were verified through an extensive survey performed for the Corps of Engineers.

Projections of waterborne shipments and receipts were distributed among PSA-to-PSA (BEA-to-BEA) links on the basis of historical (1976) distributions, adjusted according to information acquired through interviews conducted during the course of the study. For each PSA-to-PSA link, further distributions were made among port equivalent (PE) links. These distributions also were based on historical (1976) distributions. When industry sources indicated likely future shifts in the historical distribution among PE-to-PE links, appropriate adjustments were made.

II. OHIO RIVER SYSTEM HINTERLAND

Production and consumption levels and characteristics are the major determinants of commodity movements to, from, and within an area. For this study, analyses and projections of production and consumption trends were limited to PSAs (BEAs and BEA segments which historically have been the ultimate origins or destinations of waterborne commodity movements in the Ohio River System). Identification of the PSAs was accomplished by interviewing major shippers and receivers, government agencies and research personnel at educational institutions.

For most commodity groups, ORS traffic is shipped to or from plants located near the waterway or distribution centers which serve areas adjacent to the waterway. Therefore, the PSAs for Groups III, IV, VI, VII, VIII, IX, X, XI, XII, XIII, XIV, and XV are waterside BEA segments which exclude counties beyond a 20-mile radius of the waterway.

Petroleum fuels (Group II) also are shipped to intermediate distribution centers, but the service areas which determine the demand at these distribution centers generally extend beyond a 20-mile radius of the waterway. For this commodity group, entire BEAs were identified as ultimate origins and destinations of waterborne shipments.

Coal (Group I) and grains (Group V) are shipped considerable distances by rail and by truck to waterway transfer points along the waterway and then shipped by water. For these two groups, the PSAs (ultimate origins or destinations) consist of both waterside and non-waterside BEAs and BEA segments. Through a telephone survey, points of consumption and production of waterway shipments were identified. During the survey, approximately 100 coal docks were contacted about the origin, destination and the size of coal shipments. Very often the consumption point of a shipment could be

identified from the Dock Reports supplied by the Corps of Engineers. These consumption points included utility and steel plants, and consumption of coal was assumed to occur at or near these plants.

Approximately 30 waterside grain shippers and receivers were contacted to identify the points of production and consumption for ORB grains. Shippers and receivers either were located in areas of the Ohio River Basin, which are "drawing" regions for the grains produced north of the Ohio River, or were distributors serving the southeast poultry market. These sources identified non-waterside suppliers and/or customers, their locations, and the sizes of shipments. For all commodity groups, including coal and grains, shipments and receipts to and from the BEAs and BEA segments which are ultimate origins or destinations of ORS waterborne traffic were allocated among relevant port equivalents (PEs) in the ORS.

III. DETERMINATION OF HISTORICAL PRODUCTION AND CONSUMPTION LEVELS

The PSAs (BEAs and BEA segments) are aggregations of counties. Thus, to determine historical production and consumption by PSA for each of the commodity groups, estimates of county-level production and consumption were either obtained from published sources or estimated. In many cases, county estimates were made by disaggregating existing national, regional, or state production/consumption data on the basis of such distribution factors as county employment, earnings, population, or production capacity.

Three primary sources of information were used to determine historical production and consumption levels: the U.S. Bureau of Mines, the U.S. Department of Agriculture, and the U.S. Department of Commerce. Supplemental information was obtained from industry associations and regional educational and research institutions. In addition, when relationships among commodity groups were identified, estimates of production and/or consumption in one group were often used to estimate elements of production and/or consumption in another group. Because of the primary data sources, and the care taken to use a common set of economic parameters and base assumptions for all commodities and commodity groups, the PSA estimates generally are consistent and comparable.

A. U.S. Bureau of Mines Data

Bureau of Mines data were used to estimate components of production and/or consumption for 8 of the 15 commodity groups: Group I--coal and coke; Group II--petroleum fuels; Group III--crude petroleum; Group IV--aggregates; Group VII--ores and minerals (estimates of the consumption of manganese ore, sulfur, rock salt, zinc ore and concentrates, alumina ore and concentrates and production of zinc ore and concentrates); Group XII--rubber, plastic, nonmetallic mineral products (estimates of the production and

consumption of lime and cement); Group XIII--nonferrous metals and alloys, nec.; and Group XV--others, nec. (estimates of the production and consumption of petroleum and coal products, nec.).

The Bureau of Mines annually compiles statistical data from information supplied by mineral producers, processors and users in response to production and consumption surveys. Other information is gathered by the Bureau from the trade and technical press, industry contacts and numerous other sources. In addition, regional offices of the Bureau periodically gather information and conduct studies on resources and reserves, environmental matters, and other subjects. These data and study results are distributed to universities, libraries, stockbrokers, commodity dealers, economists, government officials, and members of the mineral industry.

B. U.S. Department of Agriculture

The various state statistical reporting services of the U.S. Department of Agriculture estimate annual county level production of major crops and selected livestock categories. Data are gathered from farmer reports, business firms, township and county assessors, and sample surveys in which plant populations and fruiting characteristics are measured. Consumption estimates for agricultural commodities are largely based on the 1964, 1969 and 1974 editions of the Census of Agriculture.

C. U.S. Department of Commerce

Three major Bureau of the Census publications were used in developing estimates: the Census of Transportation, County Business Patterns, and the Census of Manufactures. In addition, county-level population and earnings/employment (by sector) data were supplied by the Bureau of Economic Analysis.

The Census of Transportation is conducted every five years. One component of this study is the Commodity Transportation Survey, a prime objective of which is to measure the transportation and geographic distribution of commodities shipped by manufacturing establishments in the United States beyond local areas. The shipper survey collects data relating to the volume of commodities shipped by means of transport, length of haul, size of shipment, and areas of origin and destination. The data sources are bills of lading from a sample of approximately 13,000 plants.

For a few relatively minor commodities and products, production or consumption estimates (in tonnage measurements) were not available, and Census of Transportation estimates of shipments and/or receipts served as a basis for estimation. This means of estimation was used to measure production and consumption of Group XIV products (fabricated metal products, machinery products, electrical machinery products and ships and boats); the industrial consumption of wheat flour, sugar, soybean oil, and corn oil (components of Group IX); and the production of Group VI products (industrial, agricultural, and miscellaneous chemicals). These groups encompass a great variety of products with a wide span of value to weight relationships.

Employment data, by county, by Standard Industrial Classification (SIC) are provided by County Business Patterns. These data are collected from Internal Revenue Service quarterly payroll files, the Social Security Administration, and Annual Organization Surveys conducted by the Bureau of the Census. Employment data were used to distribute domestic consumption of industrial chemicals, by major consuming industry, and the state production of agricultural, industrial and miscellaneous chemicals.

County employment data for the food and its kindred product industry were used to distribute the regional industrial consumption of Group IX products (specifically, wheat flour, sugar, soybean oil and corn oil). Employment in the printing and publishing industry was the basis for determining PSA consumption of paper products. Industrial naphthas (Group XI) are mostly consumed by the chemical industry; thus, employment in the chemical and allied products industry was used to distribute state consumption estimates of industrial naphthas. These employment data were used to distribute among counties the domestic consumption of Group XIII products, nonferrous metals and alloys, nec., by product and by major consuming industry, as well as to allocate the national production of particular metal industries. For Group XIV, manufactured products, nec., state-level production estimates, derived from the Census of Transportation, were disaggregated to PSAs using employment in three industries (fabricated metal products, machinery products and electrical products).

In addition to using county-level employment data by industry, from County Business Patterns, statistics regarding population and earnings by sector (e.g., manufacturing, agriculture) provided by the Bureau of Economic Analysis on computer tape, were employed to disaggregate national and state consumption estimates of several

products. The population data were used to distribute the following commodities among PSAs:

<u>Group</u>	<u>Commodity</u>
II: Petroleum fuels	Fuels consumed in household, commercial, and transportation uses
IV: Aggregates	Sand, gravel, and crushed rock consumed by the construction industry
VII: Ores and minerals	Rock salt consumption
XI: Petroleum products, nec.	Consumption of lubricants, asphalts, road oil, and special naphthas
XII: Rubber, plastic, nonmetallic minerals, nec.	Cement consumption
XV: Others, nec.	Consumption of petroleum products and slags

Total earnings data from the Bureau of Economic Analysis were used to distribute to PSAs the regional consumption of Group XIV products, manufactured products, and petroleum fuels consumed in industrial uses by state (a component of Group II).

The Census of Manufactures was used to determine relationships among products. The Census is conducted every five years and provides data pertaining to inputs of labor, materials and capital, and outputs of products and services. More than two million companies participated in 1972. For Group IX, corn mill production was estimated using the relationship of industrial corn consumption to mill production. For Group X, lumber production was estimated using the relationship of production to employment. The Census of Manufactures also issues special reports. From one report, Consumption of Selected Metal Mill Shapes and Forms, production and consumption estimates by SMSA were obtained for steel mill products.

D. Interrelationships of Commodity Groups

Estimates of production and/or consumption developed for a commodity group often were used to estimate production and/or consumption when relationships between the two products were identified. Table 1 presents a summary of the interrelationships of estimates.

Table 1. Ohio River Basin Study: Interrelationships of Estimates of Historical Production/Consumption Levels

Source		Result	
Group	Commodity/Product	Used to derive:	Group
I.	Production of coke	Production of coal products	XV
III.	Consumption of crude petroleum	Production of other petroleum products, nec.	XV
V.	Consumption of corn by livestock	Consumption of food and feed products by livestock	IX
V.	Corn, wheat and soybean processing capacity	Production of food and feed products	IX
VI.	Production of chemicals and chemical fertilizers	Consumption of sulfur	VII
VI.	Production of chemicals and chemical fertilizers	Consumption of lime by the chemical industry	XII
VIII.	Production of pig iron	Consumption of coke by the steel industry	I
VIII.	Production of pig iron	Production of iron slag	XV
VIII.	Production of steel	Consumption of coal products	XV
VIII.	Production of steel	Consumption of lime by steel industry	XII
VIII.	Production of steel	Consumption of aggregates by steel industry	IV
XII.	Production of lime and cement	Consumption of aggregates by lime and cement industries	IV
XIII.	Production of primary zinc	Consumption of zinc ore	VII

Source: Robert R. Nathan Associates, Inc.

BEST DOCUMENT AVAILABLE

IV. HISTORICAL TRAFFIC STATISTICS

Data pertaining to historical waterborne commerce in the ORS were provided by the Corps of Engineers. Data reflecting rail movements, provided through the Corps of Engineers by the Interstate Commerce Commission (ICC), came from the ICC One Percent Railroad Waybill Sample. Because of limited available truck data, it was necessary to develop independent estimates of historical truck movements.

A. Waterborne Commerce Statistics

Waterway commodity flows were obtained from the master files used by the Waterborne Commerce Statistical Center in preparation of Waterborne Commerce of the United States, Part 2. The Corps of Engineers provided annual data for the period 1969-76 regarding waterside origins and destinations (both BEA and port equivalent) for all barge traffic to, from and within the Ohio River System. These data include the classification of barge movements by four-digit Waterborne Commerce Statistics Codes (WCSC).

Data computed by the Waterborne Commerce Statistical Center are collected by several offices of the Corps of Engineers in compliance with various acts of Congress. The waterborne statistics are not the result of a sample. They are compilations of traffic reports required for all movements. Although the waterborne commerce information is one of the best national collections of transportation data, there have been some problems with misclassification of commodities and with multiple- or non-reporting of shipments when more than one barge operator is involved in a barge movement. The 1976 waterborne commerce data used in this study were revised to reflect the results of an extensive survey performed by the Corps of Engineers and Battelle Laboratories to refine the data base.

B. ICC One Percent Waybill Tapes

The major source of rail information used in this study was the One Percent Waybill Statistics compiled by the Interstate Commerce Commission (ICC). These data report tonnages by origin and destination points, by seven-digit Standard Transportation Commodity Code (STCC), originating and terminating rail carrier, mileage, carload rate, freight charges, and other information.

The information is obtained from waybills submitted by terminating rail carriers. Most waybills represent one-car shipments, and adjustments are made for multicar movements. The sampling is designed to obtain data for every 100th car. The sample includes import, export, transit, rebilled and piggyback (trailer-on-flat car) traffic. Traffic originating in Mexico and Canada is excluded.

Since ICC waybill statistics are samples, the data provided by the ICC required adjustment to obtain estimates of total traffic, by commodity, by origin and destination. Sampling error exists; conversations with analysts in ICC indicated that the accuracy of estimates would be enhanced if adjustments were made by commodity and by rail carrier. An adjustment procedure was developed.

From the waybill sample, total rail traffic reported on the waybills by commodity (at the two-digit STCC level) and major terminating rail was obtained. Eleven rail carriers in the Ohio River Basin were selected: Baltimore and Ohio, Louisville and Nashville, Norfolk and Western, Chesapeake and Ohio, Illinois Central, Burlington Northern, Chicago and Eastern, Erie Lackawana, Penn Central, New York Central and Southern Railways. These sample totals were compared with totals reported by the railways as their actual national tonnage by commodity. Thus, factors were developed which were applied to sample data, by rail and by commodity, to estimate total traffic. For reported movements with rail carriers not included among the selected 11 rail carriers, a weighted average of the factors was employed. This procedure was used to determine rail traffic flows for 1969, 1972 and 1976.

There are several limitations with respect to the ICC data. The adjustment procedure discussed above reduces the sampling error, but not entirely. Adjustment factors were computed using national totals, and do not account for variations among geographic regions which could occur in the sample. The sample may miss small occasional movements, since only 1 percent of the waybills are

sampled. On the other hand, if the sample receives a waybill for one of the smaller movements, the tonnage may be overvalued. The adjustment procedure accounts for only part of this problem.

Review of the 1969, 1972 and 1976 rail data showed considerable variation for a few of the commodities. Most of these variations did not reflect the comments of shippers and receivers or analysis of production and consumption trends during the period. Rather, these differences illustrated the limitations of the sample. Year to year, accuracy of the sample varies. However, ICC analysts believe the accuracy of the data progressed as reporting procedures were developed and reporting rails grew more accustomed to the survey. Review of the data did indicate that 1976 data were adequate for the purposes of estimating rail shipments and receipts by BEA within the Ohio River Basin.

No adjustments were made for multi-modal movements, e.g., rail-to-water shipments, because of incomplete information. This presented no difficulty in making projections, except for coal. There are significant rail-to-water movements of coal and some double-counting exists. Some movements of coal are reported in both rail and water shipments. Since truck is determined as the residual of total shipments less water and rail, a rail-to-water movement is subtracted twice from total shipments. The extent of this double-counting is not known. This did not weaken the validity of projections of water and rail shipments, since these projections were based on production, consumption, and total net shipments by BEA and specific information provided through interviews. What is implicit in the projections is that rail-barge shipments from any BEA will increase at the same rate as the total barge traffic, subject to adjustments based on specific data.

C. Estimation of Net Truck Shipments

Collection of truck information involved severe difficulties. Available truck data are limited and are not useful for analyses regarding modal split. Every two years, the Federal Highway Administration conducts a truck commodity survey for which survey information is collected during an eight-hour period at approximately 220 weigh stations on interstate and other Federal highways. The information gathered includes tonnages and type of commodity. No origin and destination data are collected, and state highway movements are not recorded, so many short-haul movements are missed. Also, there is no means of identifying movements that are multi-modal, i.e., those truck movements which have involved rail or barge transportation.

Another source of truck information is the Census of Transportation, published by the U.S. Department of Commerce. Origins and destinations are reported at the regional level, but this information provides little basis for estimates at the BEA level. Also, movements under 25 miles are not reported, and therefore many local movements are not included. As with the truck commodity survey, the Census of Transportation provides no data regarding the size of multi-modal movements.

From production and consumption data, and reported water and rail shipments, net (outbound less inbound) shipments for truck can be estimated. This estimate of net truck cannot be used to estimate inbound, outbound or local movements. The example of 1976 movements of manufactured products illustrates this estimation problem. Available data were estimated as follows:

Manufactured Products, Nec.
(Thousands of tons)

Production	7,499.0
Consumption	6,546.8
Total net shipments	902.2
Water, net	20.8
Outbound	103.8
Inbound	83.0
Local	164.8
Rail, net	668.8
Outbound	1,593.8
Inbound	925.0
Local	345.7
Truck, net	212.6

There is a large set of inbound, outbound and local truck movements which would satisfy the conditions above. If, for example, inbound traffic by truck was estimated to have been 1,000.0 thousand tons, outbound truck shipments were 1,212.6 thousand tons (1,000 + 212.6); if all shipments are assumed to require some

movement (by rail, water or truck),¹ local truck could have been estimated as follows:

Total production	7,449.0
Less water exports	103.8
Less rail exports	1,593.8
Less truck exports	<u>1,212.6</u>
Production consumed locally	4,538.8
Less local water	164.8
Less local rail	<u>365.7</u>
Local truck	4,028.3

However, if inbound traffic of manufactured products by truck was estimated to have been 2,000.0 thousand tons, then outbound shipments would be 2,212.6 thousand tons, since net truck would have been 212.6 thousand tons. Local truck (including captive consumption) would be 3,028.3 thousand tons.

Truck Movements

	<u>Example 1</u>	<u>Example 2</u>
Inbound	1,000.0	2,000.0
Outbound	1,212.6	2,212.6
Local (including captive consumption)	<u>4,028.3</u>	<u>3,028.3</u>
Gross truck	6,240.9	7,240.9

Given the constraints of time, an estimation process for measuring gross truck shipments would have resulted in meaningless data. Furthermore, to estimate future waterway movements, gross truck movements were not required. Most projections were based on the historical relationship of net water shipments to total net shipments, or the relationships between production and waterborne shipments, and between consumption and waterborne receipts.

1. The assumption that all production moves to the point of consumption by water, rail or truck is not valid. Some production is captive, i.e., produced and consumed in the same facility.

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V. DETERMINATION OF FUTURE PRODUCTION AND CONSUMPTION LEVELS

The projections of consumption and production in the ORB are reflective of RRNA's judgment, at the time the projections were prepared, as to the most probable future. These projections were usually based on existing national and regional projections prepared by Federal agencies. None of the sources used in the projection of ORB production/consumption had available estimates for the entire projection period 1980-2040. These long-term projections were developed by RRNA and usually assumed less rapid rates of increase than short- and medium-term projections. These projections are based on discussions with industry authorities and researchers and represent a "consensus" regarding long-term economic and energy growth.

The projections of production and consumption developed for this study can be categorized as follows:

1. Energy-related industrial production and consumption
2. Non-energy ores, minerals, metals production and consumption
3. Agricultural production and consumption
4. Other production and consumption.

A. Projections of Energy-Related Production and Consumption

The U.S. Department of Energy (DOE) was the source (directly or indirectly) for most of the projections made for the production and consumption of Groups I (Coal and coke), II (Petroleum fuels), III (Crude petroleum) and XI (Petroleum products, nec.). The DOE projections of energy supply and demand are generally based on models which explicitly account for various sources of energy, and supply/demand characteristics for the different kinds of energy,

and which recognize the spatial aspects of the economy. In addition, the projections are tied to a macroeconomic model that generates the level of income and prices which drive energy demand. Finally, adequate detail of the coal and petroleum industries (producers and consumers) is provided to draw inferences about supply and demand in the future.

Coal has been and will continue to be the major commodity transported in the ORS. As such, considerable investigation and examination were required to select the appropriate base for projections of coal. Several recent models providing projections of coal consumption and production in the United States were examined to identify those which would be most useful in projecting waterborne movements of coal in the ORS.

Some projections of coal supply and demand are based on models which have adequate coal market structures, but which do not account for other energy sources. Explicit assumptions about the prices and quantities of other fuels are made independently for these models. Since the waterborne commodity projections include projections of other energy sources, such as petroleum, it was decided that these coal specific projection models and their results should not be used. Models falling into this category include the Argonne Coal Market Model, the Bechtel RESPONS Model, and the CRA/PEPCO Coal Market Model.

A second group of models examined includes broader energy models which project the supply and demand of coal, as well as other forms of energy. The analyses and projections of coal are generally made in significant detail. Unfortunately, these models predict only the aggregated production and consumption of coal in the United States. For instance, changes in the future locational pattern of coal production were not captured in these projections. Meaningful disaggregation of these data would have been difficult,

1. Energy Modeling Forum, "An Assessment of Results Obtained by the Argonne Coal Market Model;" "An Analysis of Coal in Transition: 1980-2000, as conducted by the Regional Energy System for the Planning and Optimization of National Scenarios (RESPONS) Model;" "CRA-PEPCO Coal Market Model Applications for the Energy Modeling Forum;" Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978), Vol. III.

and therefore none of these models was used. Models in this category include the Brookhaven TESOM, Dartmouth FOSSIL1, and the Gulf/SRI models.

The model developed by Oak Ridge National Laboratory (ORNL) also was carefully examined.² Essentially, this model disaggregates national projections of energy demand and supply by fuel type and user for BEAs. ORNL developed projections to 1980 and 1985 of energy supply and demand patterns in the United States, for each of the nine census regions, 50 states and 173 BEAs. These supply and demand projections were made for seven fuel types and four final consumers. The distribution procedure used historical and forecasted regional characteristics to allocate production and consumption totals. Projected regional economic and demographic characteristics were based on OBERS projections. Unfortunately, the latest model was based on 1975 Federal Energy Administration projections of energy use which were revised in the 1977 DOE Annual Report.³ Consequently, only the BEA distribution factors provided in the Oak Ridge model are currently valid.

The DOE projection series presented in the Annual Report includes three scenarios about economic growth, three demand levels, and three supply levels (Table 2). The economic variables are provided through integration with the projections developed by Data Resources, Inc. (DRI).⁴ These economic variables drive the energy model, which then feeds back into the DRI economic model to ensure simultaneous integration of the energy and economic models.

1. Energy Modeling Forum, "Demand Consideration, Brookhaven TESOM Model;" "A Behavioral Description of the FOSSIL Model;" "Implementation of the EMF's 'Coal in Transition' Scenarios with the Gulf/SRI Model;" Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978), Vol. III.

2. Oak Ridge National Laboratory, Regional and Urban Studies Section, Energy Division Research, Energy Available for State and Local Development: A Methodology and Data Overview. By P.L. Rice and D.D. Vogt, sponsored by the Economic Development Administration of the U.S. Department of Commerce (Oak Ridge, Tennessee: ORNL, 1978).

3. U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, 1977 ed. (Washington, D.C.: GPO, 1978).

4. Energy Modeling Forum. "Results of the DRI/Zimmerman Coal Model," Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978), Vol. III.

Table 2. National Energy Consumption Projections
under Alternative Assumptions
(Average annual percentage change)

Projection series assumptions		Gross national product			Energy consumption		
Economic growth	Energy supply	Actual 1965-1975	Projected		Actual 1965-1975	Projected	
			1975-1985	1985-1990		1975-1985	1985-1990
A. High	High	2.6	4.3	3.0	2.8	3.2	2.5
B. High	Low	2.6	4.2	3.0	2.8	3.1	2.4
C. Medium	Medium	2.6	4.1	3.2	2.8	3.0	2.8
D. Low	High	2.6	3.9	2.6	2.8	2.7	2.0
E. Low	Low	2.6	3.8	2.5	2.8	2.6	2.0

Source: U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, Volume II, 1977, p. xix.

The medium projection series of DOE was selected for projections of coal and petroleum consumption and production. This series assumed moderate economic growth and moderate growth in the demand for energy. The average annual growth rate in GNP is 4.1 percent for the period 1975-85, and 3.2 percent between 1985 and 1990. U.S. energy demand will grow at an average annual rate of 3.0 percent in 1975-85 and at 2.8 percent in the period 1985-90. As described above, the energy consumption levels are determined by the rate of economic activity, subject to constraints in the energy sectors.

In addition to using DOE projections of national and regional consumption and production of coal and petroleum products (crude oil, fuels), the projections prepared by Oak Ridge National Laboratory were used to disaggregate the DOE projections to a BEA level.

For coal and petroleum, satisfactory long-term projections are not available. Beyond the year 1990, projections of coal (excluding metallurgical) demand in the PSAs have been based on U.S. Water Resources Council OBERS projections of personal income and projections of the future relationship between Gross National Product (GNP) and energy demand. Metallurgical coal demand was based on Group VIII (Iron ore, steel and iron) projections. Projections for the production of coal beyond 1990 have been based on the ICF, Inc. Coal and Electric Utility Model projections. These projections, developed for the Federal Energy Administration, consider the capacity of existing mines and the possibility of opening new mines. For the other components of coal and petroleum, assumptions were developed regarding national trends with respect to these commodities (see individual reports for further description).

For the three petroleum-based groups, Petroleum fuels (Group VI), Crude petroleum (Group III), and Petroleum products, nec. (Group XI), projections made for one product often served as a basis for projections for other elements.

B. Projections of Non-Energy Ores, Minerals and Metals Production and Consumption

National projections of production and consumption, provided by the U.S. Bureau of Mines (BOM), were used for the projections of PSA production and consumption of the non-energy nonferrous ores, minerals and metals. For many minerals, the BOM projections are the only available long-range tonnage projections (up to the year 2000). Even if other projections matched the projection period and

types of minerals included in the BOM projections, it is unlikely that they would match the quality of BOM projections. Since 1967, the Bureau has developed and improved a methodology for projections based on analyses of end use. Commodity specialists of the Bureau of Mines have access to an extensive data base which includes information such as production, prices, and the size and location of reserves. They are also in close contact with state and local authorities, researchers, and industry specialists.

Bureau of Mines projections were used to estimate future levels of:

Consumption of aggregates	(Group IV)
Production of zinc	(Group VII)
Consumption of cement	(Group XII)
Consumption and production of nonferrous metals and alloys, nec.	(Group XIII)

Projections of the Bureau of Mines were considered when developing projections of steel supply. Review of two sources of long-term projections of national production, Bureau of Mines and OBERS, revealed no major differences between the two. However, the OBERS projections provide BEA-level projections and could be directly applied to historical production levels. BEA-specific growth projections derived by OBERS were examined and compared with the comments of some major steel producers in the Ohio River Basin. Therefore, the OBERS projections were used as a major input to projections of steel production and consumption by BEA.

The OBERS projections of population and earnings, by industry and by BEA, were also used to disaggregate several of the national-level projections of production and consumption prepared by the Bureau of Mines. This was done for consumption of aggregates by the construction industry (Group IV), consumption of steel mill products (Group VIII), cement consumption (Group XII), and the consumption and production of nonferrous metals and alloys (Group XIII) commodities.

Another major source for the projection of future production and consumption levels of individual metallic commodities were projections prepared by RRNA for other commodities.

1. Projections of earnings in the primary metals industry from U.S. Water Resources Council, OBERS Projections: Regional Economic Activity in the U.S., Series E, 1972 ed. (Washington, D.C.: GPO, 1974).

The other commodity/projections used to project non-fuel ores, minerals and metals are as follows:

<u>Group</u>	<u>Commodity/ product</u>	<u>Derived from:</u>	<u>Commodity/ product</u>	<u>Group</u>
IV	Industrial consumption of aggregates		Production of: cement lime pig iron steel	XII XII VIII VIII
VII	Consumption of manganese ore and concentrates		Production of steel	VIII
VII	Consumption of sulfur		Production of chemicals and chemical fertilizers	VI
VII	Consumption of zinc ore and concentrates		Production of zinc	XIII
VII	Consumption of aluminum ores and concentrates		Production of aluminum	XIII
XII	Consumption of lime		Production of steel	VIII
			Production of chemicals and chemical fertilizers	VI

C. Projections of Agricultural Production and Consumption

The projections developed for grains (Group V), chemical fertilizers (Group VI), and feed products (Group IX) were based on agricultural projections developed by the Economic Research Service, U.S. Department of Agriculture (USDA). Projections of wood

and paper products were based on projections developed by the Forest Service, U.S. Department of Agriculture, and the OBERS Projections.

C-1. U.S. Department of Agriculture: National Inter-regional Agricultural Projections Systems

The USDA National Interregional Agricultural Projections System (NIRAP) provides nationally and interregionally consistent projections under a wide range of assumptions. The model starts from the national aggregate level and disaggregates national projections to regional and state levels by individual commodities. Factors such as historical commodity production and utilization, cropland availability, and anticipated future food prices are considered in the model.

NIRAP system scenarios are precise statements of assumptions and/or projections required to describe the "environment" of the agricultural economy. The baseline scenario was chosen with ranges for major attributes, such as income, which cause non-price related shifts in the demand and supply of major commodities. The model allows for adjustments in response coefficients and elasticities, where logic and consistency require, to allow for changes in producers' and consumers' responses to price.

The baseline can be interpreted as the midpoint of possible combinations of attribute values falling in a range considered manageable.

The projected demand and supply attributes for the baseline food and agricultural scenario for 1985, 1990, and 2000 for the United States are presented in Table 3.

State level projections by commodity are generated by USDA for the years 1985, 1990, and 2000, providing a consistent and comparable set of projections. These are generally regarded as the best set of state-level commodity level projections available.

C-2. Application of NIRAP Projections

For the period 1969-76, PSA shares of state livestock production (for each of 11 livestock categories) were determined. Estimates of future shares were developed using regression analysis and

Table 3. Grains: Projected Demand and Supply Attributes, Baseline Scenario, 1985, 1990 and 2000, United States

Attribute and level	Actual 1975-77	1985	1990	2000
Demand				
<u>Population growth</u> (millions) Series II	215.2	232.9	242.3	260.4
<u>Economic growth (GNP)</u> (billions 1972 dollars) Moderate (3.0 percent/year)	1,271.4	1,594.4	1,848.4	2,484.0
<u>Economic growth (per capita disposable income)</u> (1972 dollars) Series II population - moderate GNP	4,148.0	4,876.0	5,497.0	7,005.0
<u>Tastes and preferences</u> (percent meat substitutes)	2-5	2-5	2-5	2-5
<u>Agricultural trade</u>	High	Moderate	Moderate	Moderate
Supply				
<u>Public expenditures for agricultural research and extension program</u> (millions 1972 dollars) 3.0 percent growth	795.0 ^a	1,155.8	1,339.0	1,800.7
<u>Inflation index</u> (1972 = 100) Moderate (5.0 percent year)	116.0	171.0	218.3	355.6
<u>Climate (Index)</u> ^b Neutral	97.0	101.6	101.6	101.6

a. 1973-75 average.

b. The Stallings' weather index. This index is designed to measure the direct influence of weather and the indirect influence of insects and disease on agricultural output. Variables such as crop variety, soil and certain cultural practices are held constant. The index is computed as the ratio of the actual to the computed yields of a linear regression. An index value of 100 is normal weather. Adverse weather would yield values less than 100 and better than normal weather would yield values greater than 100.

Source: Leroy Quance, et. al., Adjustment Potential in U.S. Agriculture, Volume I: Scenario, Production, Price and Income Projections to 1985, 1990 and 2000, U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, Economic Projections and Analytical Systems, National Economic Analysis Division, Washington, D.C.: n.d.

the judgment of commodity specialists. These PSA shares were then applied to USDA state-level projections of livestock production.

PSA livestock production projections were multiplied by feed rations (as specified by USDA) to project livestock consumption, by PSA, of grains (Group V).

Similarly, future PSA shares of state-level corn, wheat, and soybean production were developed through regression analysis and by use of judgment. These PSA shares were applied to USDA state-level projections to obtain projections of grain production by PSA.

The projections for the consumption of food and feed products (Group IX) by livestock (prepared animal feed, grain mill products, and molasses) were derived from the projections of corn consumption by livestock (Group V), mentioned above.

Group V projections of production were used in the projection of chemical fertilizer consumption. PSA-level grain production was divided by yield per acre, as estimated by USDA, to estimate acres harvested. Projected fertilizer application rates, developed by staff of the National Fertilizer Development Center, were applied to projected acreage to yield consumption of fertilizer.

C-3. OBERS Projections

The OBERS Projections,¹ prepared for the U.S. Water Resources Council, were developed by the Bureau of Economic Analysis, U.S. Department of Commerce, and the Economic Research Service, U.S. Department of Agriculture. These projections are based on long-run or secular trends, and ignore cyclical fluctuations which characterize many of the short-run forecasts of the economy. The general assumptions that underlie the projections are as follows:

1. Population growth is estimated according to the Bureau of the Census 1972 Series E national population projections.
2. A national unemployment rate of 4 percent is assumed to prevail until 2020.
3. Technological progress and capital accumulation are ensured to support a growth in private output per man-hour of 2.9 percent annually.

1. U.S. Water Resources Council, OBERS Projections, Regional Economic Activity in the United States, Series E, 1972 ed. (Washington, D.C.: GPO, 1974).

4. For regional forecasts, most regional factors are expected to converge toward the national norm.

The OBERS projections of timber production are based on a detailed analysis of prospective growth in the major timber-using industries, such as construction, manufacturing, and shipping. In making the projections, it was assumed that future price trends for timber products will not differ significantly from price trends for competing materials.

OBERS was the basis for projections of lumber and pulpwood log production (Group X). The Forest Service, USDA, provided projections of consumption. Paper product production and consumption projections were derived from the Construction and Forest Division of the U.S. Department of Commerce. Table 4 presents a summary of the projection methodology for Group X.

OBERS projections of earnings in the food and kindred product industry also were the basis for most of the production and consumption projections developed for Group IX (food and feed products).

D. Projections of Other Production and Consumption

Projections of production and consumption of others, nec. (Group XV) primarily were based on projections developed for other commodity groups. Group XV commodities include petroleum and coal products, iron and steel slags, and waterway improvement materials. Groups I, III, and VIII provided the basis for Group XV projections.

Earnings projections from OBERS projections were used for projections of chemical production and industrial chemical consumption (Group VI) and for projection of manufactured products (Group XIV). Some of the assumptions which underlie the OBERS projections were presented earlier.

Review of other projections of industrial activity did not identify reasonable alternatives to OBERS projections. OBERS projections are long-term (to the year 2020) and were available by BEA and by major industry. Short-term national projections were examined and yield no major differences with OBERS.

When OBERS projections were used, the projected growth in earnings (or population), by BEA, for the period 2020-40 was

Table 4. Ohio River Basin: Summary of Projection Methodology
for Wood and Paper Products

Variable	Basis for projection	Allocation methodology
Lumber production	Projection of roundwood production by state provided by U.S. Water Resources Council, <u>1972 OBERS Projections</u> , Volume 1, pp. 106-107	Growth rate of roundwood production computed for each state. Rates applied to lumber production in BEAs and BEA segments within each state
Lumber consumption	U.S. Department of Agriculture, Forest Service, <u>The Nation's Renewable Resources--An Assessment</u> , 1975, Table 60, p. 147, medium projection	U.S. lumber consumption allocated on basis of earnings in lumber products and furniture industries in BEAs and BEA segments
Pulpwood log production	U.S. Water Resources Council, <u>1972 OBERS Projections</u> , Volume 1, pp. 106-107, projection of pulpwood production, by state	Growth rates of pulpwood production computed for each state. Rates applied to lumber production in BEAs and BEA segments within each state
Pulpwood log consumption	U.S. Department of Agriculture, Forest Service, <u>The Nation's Renewable Resources--An Assessment</u> , 1975, Table 63, p. 156.	U.S. pulpwood consumption allocated on basis of earnings in paper products industry in BEAs and BEA segments
Paper product production	U.S. Department of Commerce, Construction and Forest Division, Model II, unpublished data (1980 projection); projections for later years are made by RRNA	U.S. paper production allocated on basis of earnings in paper products industry in BEAs and BEA segments
Paper product consumption	U.S. Department of Commerce, Construction and Forest Division, Model II, unpublished data (1980 projection); projections for later years are made by RRNA	U.S. paper product consumption allocated on basis of earnings in printing and publishing industries in BEAs and BEA segments

assumed to equal one-half the growth in earnings (or population), by BEA, projected by OBERS for the period 2000-2020. This procedure is based on the assumption that as change occurs, economic equilibrium is approached and the rate of change decreases over time.

OBERS projections of earnings generally were used, although employment projections from OBERS could have served. However, projections of employment captures less of the change in productivity than does earnings.

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VI. PROJECTIONS OF WATERBORNE RECEIPTS AND SHIPMENTS

Future waterborne receipts and shipments were projected individually for each of the 15 commodity groups. These projections were developed for BEAs and BEA segments, linking BEA specific projections of production and consumption and analyses of transportation characteristics. The projections of shipments and receipts were then used as inputs to a Flow Model, the output of which was BEA-PE-PE-BEA waterborne flows.

A. Projections of PSA Shipments and Receipts

For the most part, future waterway receipts and shipments, by PSA, were estimated based on the relationships of these movements to total net shipments, by PSA in 1976, or on the relationships of these movements to production and consumption in 1976, by PSA.¹ Local movements were derived from the historical shares of shipments by PSA that were local, and adjusted based on total projected receipts (inbound plus local) within a PSA. This estimation of local traffic was made using the Flow Model described elsewhere.

Production and consumption were projected individually for the PSAs, and very often had different growth rates. Because of this, the modal split for the total ORB could change over time. If there were some PSAs with higher projected rates of growth and a high portion of water shipments in 1976 while the other PSAs have low growth rates and few water shipments, the portion of Ohio River Basin net shipments to total net and to total Ohio River Basin production/consumption will change significantly over time.

1. An exception was the projection of waterway traffic of Groups IV (Aggregates) and XII (Rubber, plastic, nonmetallic minerals, nec.) which were based on total Ohio River Basin consumption, production and modal split, and then distributed among BEAs.

B. Projections of Receipts by SCAs
and Shipments by SPAs

In addition to PSAs, external areas linked to the ORB through waterborne commerce were identified. Areas (BEAs) outside the ORB which are destinations of waterborne movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB which are origins of waterborne movements destined to the ORB are designated as Secondary Production Areas (SPAs).

Receipts and shipments for SCAs and SPAs were based on projections of receipts and shipments within the Ohio River Basin. Projections were done individually for each commodity group. Two methods were used:

1. From the 1976 waterborne commerce statistics, the portion of total shipments by BEA which was outbound (i.e., to SCAs) was determined and applied to projections of shipments of each PSA to project outbound shipments by PSA. Outbound shipments by PSA were totalled to obtain total outbound shipments. Since net shipments for the Ohio River System were already determined as the total of net shipments by PSA within the Ohio River Basin, inbound ORS shipments could be estimated as outbound minus net shipments.

Most outbound and inbound shipments by SCA and SPA were estimated using the 1976 shares of PSA shipments/receipts within the Ohio River Basin which had been shipped to/received from specific SCAs/SPAs outside the Ohio River Basin. These percentage shares were then applied to future PSA waterway shipments/receipts to estimate amounts linked to SCAs/SPAs. In some cases, SCA and SPA movements were derived by using the 1976 distribution of total inbound/outbound shipments among SCAs/SPAs.

2. The second method is very similar to the first. However, inbound waterway shipments were estimated before outbound. The 1976 portions of receipts by PSA which were inbound (from SPAs) were used.

In both cases, adjustments were made when specific information was available. For instance, iron ore, iron and steel shipments required adjustments for the projected expanded shipments of iron

scrap. The above procedures were used to obtain a base estimate of receipts and shipments, but known scrap movements were then added to the base.

For projection purposes, it was sometimes necessary to divide BEAs 46 (Memphis), 114 (St. Louis) and 115 (Paducah) since these BEAs supplied ports on the Mississippi River as well as the Ohio River System. This separation was carried through the projection process until all BEA flows were allocated to appropriate PEs. The non-Ohio River Basin segments were designated as 946, 914, and 915 and are so listed on the growth indices published in each report where used. These BEAs were aggregated (i.e., 914 shipments were added to 114 shipments) when BEA-PE-PE-BEA data were supplied to the Corps of Engineers.

Projections of receipts and shipments by BEA were then used as input to BEA-to-BEA flow projections (described in the following section). The potential impact of the Tennessee-Tombigbee Waterway was not considered, in the projection of either total receipts and shipments or waterway flows.

For Groups IX through XV, initial projections of waterborne commerce were developed from preliminary information provided by the Corps of Engineers. These initial projections were derived according to the procedures outlined above.

As more complete information was made available by the Corps of Engineers, the initial projections of BEA-to-BEA waterborne traffic were revised in the following manner:

1. Movements from BEA to BEA were projected to increase/decrease at the same rates as the initially projected movements, with preliminary estimates of 1976 tonnages replaced by actual 1976 tonnages. When additional information revealed significant differences between base year 1976 tonnages used for the initial projections and actual 1976 tonnages, new projections were developed in the same manner as the original projections.
2. When additional information revealed new BEA-to-BEA links, these movements were usually projected to increase at the same rate as projected inbound, outbound, or local movements for the PSAs as a whole. Exceptions to this procedure were made when movements were projected to increase at the same rate as production or consumption for specific BEAs which were judged to develop future movements at a slower or more rapid rate than the PSAs as a whole.

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VII. FLOW PROJECTION METHODOLOGY

The flow projection methodology essentially has been built around waterway traffic projections at the BEA level in conjunction with historical and anticipated future PE-to-PE traffic flows.

The basic premise built into the design of the methodology is that the resulting traffic patterns should reflect, as closely as possible, the existing transport cost structure.

The methodology attempts to determine future levels of traffic flows under the assumption that relative transport costs remain unchanged.¹ In essence, the transport cost structure is held constant while allowing production and consumption to change to reflect projected supply and demand conditions. The methodology thus provides the base-line case for estimating, among other things, the savings to shippers that result from future navigational improvements.

The methodology is based on a top-down approach. Use of this approach involves starting with BEA-BEA production and consumption estimates and working down -- first to BEA-BEA commodity flows and from there down to PE-PE flows. The higher levels thus serve as controls on lower levels. Thus, the methodology involves disaggregation rather than aggregation.

One of the basic concepts built into the flow generation process is that the Model's generated values, which are mathematically derived, can be overrode when specific information exists to permit a manual assignment of flows between two BEAs.

The ability to intervene manually in the solution process is one of the main features of the RRNA methodology. This ability

1. Procedures, as specified by the contract, include the assumption of constant relative transport costs.

provides a means for introducing changes in the traffic pattern which are not explainable either by historical patterns or by proportional types of adjustments. Examples for which this is important are the introduction of new traffic links and the redistribution of shipments which result from the construction or expansion of a consuming facility (such as a power generating plant) or a producing facility (such as a coal mining area).

In contrast, in using many of the commonly used transportation flow models, any manual override of the Model's results can only be accomplished by changing the input assumptions in such a way as to produce the desired value. Because computational algorithms are fixed in these models, the output will always be predetermined by the input data. Although it is highly desirable to make every input assumption explicit, it is difficult to specify the assumptions in quantitative terms. To do so requires that for every assumption there will be an appropriate input variable with specific values assigned. In many cases, the individual assumptions on future conditions are not readily quantifiable being based on discussions with industrial sources such as shippers or receivers.

The following sections contain a general discussion of the Traffic Flow Model and the manner in which it is used to generate the BEA-PE growth index records and associated matrices.

For a detailed specification of the Model's computer programs along with associated procedures files and input and output files, see the Technical Appendix (Section VIII).

A. Traffic Flow Model

The Flow Projection Model is designed to allocate the shipments associated with a set of origin BEAs to a set of destination BEAs. Tonnage flows are calculated by multiplying the projected total shipment tonnages of a given origin BEA by a coefficient representing the percentage of that shipment tonnage flowing from that BEA to a given destination in the base year. Adjustments are then made to obtain a successful solution. For successful solution of the model to exist, the total flows into each destination BEA must be equal to the total project receipts for that destination.

As long as the relative shares of shipments among all origins and the relative shares of receipts among all destinations remain unchanged, the conditions for a solution will be met. However, as some BEAs will grow at a faster rate than others, relative shares among BEAs will change which will, in turn, bring inflows out of

line with projected receipts. What the Model does is to generate a new set of coefficients which will bring inflows in line with receipts. This is done in either of two ways: through a manual adjustment reflecting specific information, or through a mathematical-type adjustment reflecting base year patterns.

The objective in using the Flow Model is to produce a matrix solution for a given year in which total flows¹ from every origin BEA equal their total projected shipments and total flows to every destination BEA equal their total projected receipts.

The output of the model for each projected year is as follows:

1. hard copy printout of the BEA solution matrix;
2. computer file containing the O-D BEA pair flows;
3. a set of computer files for use in generating flows for the next time period.

The hard copy printout is principally for use in evaluating the reasonableness of the results of a particular matrix solution. If the results are not acceptable, manual adjustments can be made and the Flow Model rerun.

The computer file of O-D BEA pairs is used in producing a growth index record for each BEA pair covering the period 1976 through 2040.

A set of computer files is automatically generated by the Model for use in generating a solution for the next time period. These files include a new set of shipment distribution coefficients and the set of changes in flows before and after the adjustment process.

Input to the Flow Model is as follows:

1. A computer file containing the projected time series of shipments for each origin BEA and of receipts for each destination BEA;

1. The use of the word flow refers to individual cells within the generated matrices. In a matrix with i number of origins and j number of destinations, there would be i times j number of flows, each representing the tonnage shipped via one Origin-Destination (O-D) BEA pair. Out-flows refer to the flows associated with origins, in-flows refer to the flows associated with destinations.

2. A computer file containing the 1976 shipment distribution coefficients for each origin BEA to all possible destination BEAs;
3. An optional computer file containing the set of manual intervention adjustments.

In solving the future BEA O-D flow matrix, the following conditions must be present:

- a. total shipment flows for every BEA must equal the projected total shipment of that BEA; and
- b. total receipt flows for every BEA must be equal to the total projected receipts of that BEA.

Condition (a) will always exist as long as the sum of the shipment percentage distribution coefficients for each shipping BEA is equal to one.

Condition (b) generally will not exist without first adjusting the base set of distribution coefficients. This occurs because projected shipments by BEA and projected receipts by BEA may all be changing at different rates. For example, if between projection periods, the total projected shipments from one BEA doubles, then the the distribution coefficients derived from the first period would generate outflows for the BEA equal to twice the outflows of the first period. However, the total projected receipts for the BEAs linked to the origin may have changed at differing rates such that there are excess tons being shipped to one BEA and a deficit elsewhere.

After all adjustments have been made such that conditions (a) and (b) are true, then a correct but not necessarily best solution will exist. This is because there is more than one set of coefficient adjustments that will result in a correct solution. Thus care must be taken to ensure that the solution results are, in fact, reasonable as well as correct.

The O-D BEA flow matrices are produced in time sequence starting with the base year which, in this case, is 1976. This is because a new shipment distribution coefficient matrix is generated after each projection year to reflect the latest traffic flow pattern. This new distribution then replaces the previously used distribution for the next time period. Thus, while the 1976 shipment distribution coefficient matrix is used as input for 1976 and

1980 matrices, the distribution coefficient produced from the 1980 solution matrix is used for 1990, and so forth through 2040.

The following is a description of the process by which the model produces an O-D BEA flow matrix.

Tonnages are calculated for each O-D BEA pair using the base year shipment distribution coefficients and the projections of shipments for each origin BEA. Because the sum of the shipment distribution coefficients for each origin BEA is 1.000, total out-flows and shipments are automatically equal.

Total in-flows are then summed for each destination BEA and subtracted from the projected destination receipts. When the difference between total in-flows and projected receipts is not zero, subsequent adjustments must be made in one or more of the individual in-flows to eliminate the difference.

The first time the Flow Model is run for a given year, the Model will attempt to produce a correct solution through a system-generated proportional adjustment. What this involves is essentially as follows:

1. The in-flows of each destination BEA, in which total in-flows and projected receipts are equal, are frozen at their current value.
2. Starting with the destination BEA with the smallest absolute non-zero difference between total in-flows and total projected receipts, a proportional adjustment is made to the in-flows so that they equal receipts.
3. Any adjustment to an individual destination BEA in-flow must be counterbalanced by an equal but opposite change in the in-flows of the other destination BEAs in order to maintain the equality between projected shipments and out-flows. In other words, if the tonnage to a given destination BEA from a given origin is increased by 1,000 tons, then a reduction of 1,000 tons must be made in the other destination BEAs served by the particular origin BEA. As the tonnage flows for those destinations with a zero difference in receipts and in-flows have been frozen at their current value, any proportional adjustment will be based entirely on the remaining non-frozen destination BEAs.

4. After the proportional adjustment for the starting destination BEA has been completed (i.e., total inputs equaling receipts), the in-flows associated with that particular destination are frozen at their new level. In-flows are then summed up for each of the remaining non-frozen destination BEAs to determine the next destination BEA to be adjusted (i.e., the one with the smallest non-zero absolute difference between receipts and total inflows).
5. The automatic adjustment process is continued until no further adjustment can be made.

For a number of reasons the results produced through the automatic adjustment may not be reasonable. First, the results are based on a proportional adjustment. This process is not able to take into account possible disproportionate adjustments resulting from anticipated changes, such as the introduction of new facilities in an area or a switch to new resource sources. Second, the automatic adjustment is prohibited from assigning flows to O-D BEA pairs with no current traffic. New links can be added only through a manual intervention. Third, because the Model freezes values after the difference between projected receipts and total in-flows has been eliminated, the Model is sometimes unable to make reasonable adjustments since the number of remaining non-zero cells available for use in counterbalancing is constantly being reduced.

When the matrix solution generated by the Flow Model's automatic process is felt to be unreasonable, either in whole or in part, then a manual intervention step is applied.

The manual intervention process is used to change any flow value considered unreasonable. Manual intervention is also used to assign values for cases not able to be handled by a proportional adjustment. Changes can be made in one of two ways: by adding or subtracting tonnage to the initial flow matrix value (before any automatic adjustment is made) or by specifying a replacement value.

To facilitate the preparation of a manual intervention file, the Model automatically generates a file containing all of the non-zero changes between the initial solution and the second solution reflecting the automatic adjustments. Those changes between solutions which appear reasonable can be left unchanged in the manual intervention file. Any change in the file can be modified as the commodity analyst deems necessary. In addition, new flow changes can be added.

The Model is then rerun, for the year in question, using the manual intervention file. In this second run, the difference between projected receipts and total in-flows are recalculated using the manual intervention value changes. If all of the differences between projected individual BEA receipts and total in-flows are eliminated as a result of the manual intervention changes, then no automatic adjustments will be applied. If, on the other hand, there are still some differences between total in-flows and receipts for any destination BEA, the system will apply a proportional adjustment to eliminate this difference.

In most cases the second run will produce a correct solution, because first, the manual intervention will eliminate most of the major differences, and second, the automatic adjustment process has fewer adjustments to make.

For each successful flow matrix solution, the Model will produce four output computer files. The first file contains, for each BEA pair, the value of the tonnage flow. This file is used in conjunction with the flows for the other time periods, to produce a growth index record for each O-D BEA pair. The second file contains a shipment distribution coefficient matrix based on the current solution matrix. This file is used as input into the generation of flows for the next time period. The third file contains all of the changes between the initial and final solution for each O-D BEA pair. This file is, in essence, the system-generated intervention file. The fourth file serves the same purpose as the third file except that it contains a replacement value rather than a change value.

B. Generation of the O-D BEA and PE Growth Index Record

Once the O-D BEA matrices have been generated for the base year 1976 and the future years 1980, 1990, 2020, and 2040, the next phase involves the generation of O-D BEA growth index records.

The input to the generation of the O-D BEA growth index records is the data files which contain the non-zero O-D BEA pair flows produced by the Model for the selected years 1976 through 2040. As a first step, the individual year flow files for a single commodity are combined together and then reordered so that the flows for each BEA pair are in time sequence (i.e. 1976, 1980,...2040). A computer program takes this file and produces a single record for each O-D BEA pair consisting of a base tonnage flow value followed by the index value for 1976, 1980, 1990, 2000,

2020, and 2040. Where there exists a non-zero flow in 1976, the base value will represent the tonnage in 1976 and the 1976 index value will be 1.0. There are, however, two exceptions to this rule. First, when the tonnage for some future time period (e.g., 1990) is more than 10,000 times greater than in 1976, the program will select, as the base year, the first time period in which no index value (over the period 1976-2040) is greater than 9,999. Second, where no flows existed in 1976, the base tonnage will represent the tonnage in the first year in which there is a positive flow. In this case the growth index values prior to the first positive year will be zero.

As a second step, the BEA growth index records are used to produce a set of PE growth index records. Essentially the PE-to-PE flows associated with a given O-D BEA pair are derived from the base year distribution of PE flows. By determining the PE distribution such that the percentage sum of all PE pairs within a BEA pair is equal to 100 percent, the individual PE flow tonnages can be obtained by multiplying these PE-PE percentages by the total tonnage flow associated with the BEA pair.

The actual O-D PE pair growth index records are generated through a computer program which uses as input the O-D BEA pair growth index record and the percentage distribution of each non-zero BEA pair. As with the BEAs, a different PE pair percentage split can be input by the commodity specialists for each of the projection years.

In the case in which the distribution of flows among PEs within a BEA is assumed to remain constant over the period through 2040, all that is necessary to produce an O-D PE growth index record is to replace the BEA pair base tonnage value with that of the PE pair serving the O-D BEA link. This is done by multiplying the O-D BEA pair base value by the PE pair percentage split. For this case, the index values will remain the same for each of the PE pairs.

When the percentage of flows among PEs within a BEA pair is assumed to change at least once during the period through 2040, both the base value and the index values on the BEA pair record will be different.

A computer program has been developed to produce a hard copy O-D BEA pair and PE pair for any commodity group, including total, for any year from 1976 through 2040. Input to the program is a

single file containing the combined O-D PE pair growth index records for all of the 15 commodity groups. For the base year 1976 and the future years 1980, 1990, 2000, 2020 and 2040, the values shown in the matrices are those produced directly by the Model. For the other years, the values are obtained through interpolation between the two closest Model-generated values.

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VIII. TECHNICAL APPENDIX

A. Computer Procedures for Generating the O-D Flow Matrices

A-1. General Discussion

A computerized procedure has been developed to facilitate the generation of O-D BEA flow matrices for the base year 1976 and the future years 1980, 1990, 2000, 2020 and 2040 for each of the 15 commodity groups. The procedure provides for a hard-copy of the O-D BEA matrix to be printed out along with a computer file containing the flows for each non-zero BEA pair. The individual year computer files for each commodity are combined in a subsequent step to produce the BEA and PE pair growth index records.

The procedure for generating O-D BEA flow matrices involves use of a flow projection model (referred to as the Model). Initial input files to the Model are: (1) the time series projections on shipments and receipts for each BEA for each commodity, and (2) the 1976 shipment distribution coefficient matrix for each commodity.

An additional, but optional, input file to the Model is the set of data required for manual intervention. A file containing these data must be specified for any commodity and any year in which some type of direct manual assignment of flows is desired. The user has the option of generating his own manual intervention file or of modifying the system-generated manual intervention file.

As soon as the necessary input fields for a commodity have been loaded into the computer and checked for any coding or key punching errors, the Model can be run. In using the Model, the O-D BEA flow matrices must be run in time sequence starting with 1976.

To initiate the Model run for 1976 for commodity group 01, it is only necessary to type in the following statement:

-ORBODF(YEAR=1976,CG=01)

To get the hard-copy output, type in the following statement after the run has been completed: LIST

In initiating a run request, a number of parameters must be specified. The only two mandatory parameters are the year and the commodity group code. The other parameters have default settings which, if not changed, require no further specification on the part of the requester. These optional parameters and their default settings are as follows:

MIN=NO: no manual adjustment is to be performed;

FRZ=NO: no rows are to be frozen;

MIFILE=: no manual intervention file name specified;

MIRV=DIFF: if a manual intervention file is used it is assumed to contain different values;

AU=YES: the automatic adjustment step is to be performed;

OUT=YES: computer output files will be generated at the end of the run;

FS=YES: the initial solution matrix, before any automatic adjustment but after any manual adjustment, is to be printed out.

To request a run for the year 2000 for commodity group 13, with manual intervention to be performed, and with the initial solution matrix not to be printed, the user would enter:

-ORBODF(YEAR=2000, CG=12, MIN=YES, FS=NO, MIFILE=M122000)

The automatic adjustment would be performed and the computer output files would be generated, at the end of the run, since the default

values for AU and OUT were not overridden in the request. To obtain a copy of the hard-copy matrix, the word LIST must be typed in when the run has been completed.

The following subsections describe the preparation of the mandatory input files plus each of the five optional parameters.

A-2. Commodity Time Series
Projection Input File

This section describes the preparation of the input file containing the BEA time series projections for a single commodity. Both shipments and receipts are included in the file. The shipment and receipt records are differentiated by coding in an "S" in Column 1 if shipments or an "R" if receipts. Tonnage values are required for 1976, 1980, 1990, 2000, 2020, and 2040.

For each BEA record the following data are required (all values must be right adjusted):

Col 1	:	an S if shipments, an R if receipts;
Col 2-3	:	the row or column sequence order of the BEA as it is to appear in the O-D flow matrix;
Col 4-6	:	the 3-digit BEA number;
Col 7-8	:	the commodity group code;
Col 9-18	:	1976 total tonnage;
Col 19-28	:	1980 total tonnage;
Col 29-38	:	1990 total tonnage;
Col 39-48	:	2000 total tonnage;
Col 49-58	:	2020 total tonnage;
Col 59-68	:	2040 total tonnage.

An additional record must be coded up indicating the number of matrix shipment records and receipt records.

The format of this record is as follows:

Col 1 : an X;
Col 2-3 : the number of shipment records;
Col 4-5 : the number of receipt records.

Files are assigned names as follows:

TSCCG

where CG is the commodity code.

Once all of the data has been loaded into the file, the file must be sorted as follows:

Major sort: Col 1 in descending order;
Minor sort: Col 2-3 in ascending order.

A-3. 1976 Commodity Shipments
Distribution Input Coefficients

This section describes the preparation of the input file containing the 1976 BEA shipment distribution coefficients for a single commodity.

The sum of the coefficient for a given origin BEA to all destinations must be equal to 1.000. The number and order of destination BEAs must be the same for all of the origin BEAs.

It is also a requirement of the model that all destination BEAs be included that are projected to receive tonnage in at least one year. For those years in which no tonnage is shipped to the destination BEA, the shipment coefficient will be zero.

In coding up the data, a maximum of 14 BEA destinations may be put on one coding line. As many as three lines or 42 BEA destinations can presently be handled without any reprogramming of the Model.

For each origin BEA record the following data are required (all values must be rightly adjusted):

- Col 1-2 : The card number, specified as 01, 02 or 03. If there are between 1 and 14 BEA destinations, only one card will be necessary; between 15 and 28, two cards will be necessary; between 29 and 42, three cards will be necessary;
- Col 3-4 : The row sequence number of the origin BEA. The number must be the same as in Col 2-3 of the shipment time series record for the given BEA;
- Col 5-7 : The 3-digit BEA number of the origin BEA;
- Col 8-9 : The commodity group code;
- Col 10 : Blank;
- Col 11-15 : The decimal equivalent of the shipment percentage coefficient for the 1st, 15th or 29th destination depending on whether the card number is 01, 02 or 03, respectively. The decimal must be coded on the record line;
- Col 16-20 : Coefficient for the 2nd, 16th, or 30th destination BEA;
- Col 21-25 : Coefficient for the 3rd, 17th, or 31st destination BEA;
- Col 26-30 : Coefficient for the 4th, 18th, or 32nd destination BEA;
- Col 31-35 : Coefficient for the 5th, 19th, or 33rd destination BEA;
- Col 36-40 : Coefficient for the 6th, 20th, or 34th destination BEA;
- Col 41-45 : Coefficient for the 7th, 21st, or 35th destination BEA;
- Col 46-50 : Coefficient for the 8th, 22nd, or 36th destination BEA;
- Col 51-55 : Coefficient for the 9th, 23rd, or 37th destination BEA;

Col 56-60 : Coefficient for the 10th, 24th, or 38th destination BEA;
Col 61-65 : Coefficient for the 11th, 25th, or 39th destination BEA;
Col 66-70 : Coefficient for the 12th, 26th, or 40th destination BEA;
Col 71-75 : Coefficient for the 13th, 27th, or 41st destination BEA;
Col 76-80 : Coefficient for the 14th, 28th, or 42nd destination BEA.

Files are assigned names as follows:

SCG1976

where CG is the commodity group code.

Once all of the data has been loaded into the file, the file must be sorted as follows:

Major sort: Col 3-4 in ascending order
Minor sort: Col 1-2 in ascending order

A-4. Manual Intervention Steps

To initiate the manual intervention step for a given year, MIN=YES must be typed in the run initiation statement. Further, if the manual intervention file is to be in the form of replacement values rather than difference values, then MIRV=VAL must also be typed in. In addition, the file name of the manual intervention file must be specified as follows:

1) If a user prepared manual intervention file is used, then type:

MIFILE=MCGYEAR (e.g., M021980)

where CG represents the 2-digit commodity code and YEAR, the 4-digit year;

2) If the system-generated manual intervention file is used, then type:

MIFILE=DCGYEAR (e.g., D051990) if the differences are to be used or MIFILE=RCGYEAR (e.g., R05-990) if the replacement values are to be used.

To create a manual intervention file from scratch, the following steps should be performed:

- 1) Examine the hard-copy matrix for the year in question;
- 2) Starting with the first row of the matrix and working across the destination columns, pencil in any new value;
- 3) Continue step 2 until all rows have been examined;
- 4) Returning to the first row, calculate the change between the new value and the old value for each column in the row (e.g., a new value of 1000 and an old value of 900 gives a change of + 100);
- 5) The sum of the changes for the row must add up to zero. If it does not, additional counter-balancing changes must be made to the row until a zero sum is achieved;
- 6) Continue steps 4 and 5 until all rows have been processed;
- 7) Write the difference between the new and old solutions if a difference file is desired or the new value of a replacement is desired onto the coding sheets as follows:

TYPE 1 Card - to indicate the row being changed.

- Col 1-2 : Row sequence number as it appears in matrix
(replace any leading blank with zero);
- Col 3-4 : 00 (double zeros);
- Col 6-8 : The 3-digit BEA row number.

TYPE 2 Card - to indicate the col, within the row, being changed:

- Col 1-2 : Row sequence number (same as TYPE 1 Card);
- Col 3-4 : Col sequence number as it appears in the matrix
(replace any leading blank with zero);

- Col 6-8 : The 3-digit BEA col number;
- Col 11-18 : The value of the change (new value minus old value) or the new value. If the decimal point is included, the value can be written starting in Col 11, otherwise the value must be right adjusted. If a replacement file is used and a new value of "0" is to be used then it must be coded as 0.1 rather than 0.

Notes:

- a. A TYPE 2 Card is to be repeated for every column change in the row;
- b. The TYPE 1 and TYPE 2 Card sequence is repeated for every row having a change or replacement value;
- c. After the last row has been coded up, write out the following line starting in Column 1:

10000END

A further procedure exists for adding, deleting or changing the manual values contained in either the user-generated or computer-generated manual intervention files. All changes or replacement values should be coded in the same format as used in the initial file creation.

1. To change column values in any row presently included in the data file, the procedure is as follows:
 - a. To delete a column change, code up a new line with the value shown in Col 1-4 of the BEA column being deleted.
 - b. To add a column or change a value follow the TYPE 2 Card instructions as previously described.
2. To make changes to rows not presently included in the data, follow the TYPE 1 and TYPE 2 Card instruction for file creation.

To initially create a manual input change file for a given year and commodity group, type the following statements:

1. NEW, MCGYEAR where CG is the commodity group code (e.g., 01) and YEAR is the year (e.g., 1980);
2. The TYPE 1 and TYPE 2 cards using the instructions specified;
3. REPLACE

A-5. The Freezing of Specific Matrix Rows

As part of the Model any number of matrix rows can be frozen at their initial values (i.e., the value after any manual adjustment, but before any automatic adjustment has taken place). To initiate the freeze row step for a given commodity and year, FRZ=YES must be typed in the run initiation statement. Further, if not already included as part of a manual intervention operation, the "MIFILE=" parameter must be specified. In addition, the BEA numbers of the rows to be frozen must be put into a data file. In coding up the data the following format is to be used:

Col 1-5 : a unique sequence number starting with 90000;

Col 6-8 : 3-digit BEA number of row to be frozen.

After the last row has been entered on the coding sheet, write out the following line starting in Column 1:

99999END

Additional rows can be frozen or old rows unfrozen after the file has been created. To unfreeze a row, code up a new line with the value shown in Col 1-5 of the row to be deleted. To add a row, code up a new line in the format previously described making sure that the value in Col 1-5 is both greater than 90000 and unique.

As in the case with the manual input changes, the data on the rows to be frozen can be typed directly into the computer terminal. The row data are put into the same file as the manual input change data. If a manual input change file already exists, type:

OLD, MCGYEAR

If a file does not presently exist, type:

NEW, MCGYEAR

Next type in the row data following the instruction specified.
As a final step type REPLACE.

A-6. Automatic
Adjustment Step

The Model will perform the automatic adjustment step unless AU=NO is specified in the run initiation statement. The automatic adjustment step takes place after all manual adjustments have been made.

Under the default parameter settings both the initial matrix solution and a matrix solution, after automatic adjustments, are printed out. The computer output files generated from the run will reflect, however, only the final solution made (i.e., through the automatic adjustment). If it is desired that the computer generated files reflect the solution before any automatic adjustment, then AU=NO must be specified.

A-7. Computer Files
Generated By the Model

The Model will automatically output four computer files if the run is successful. The first output file contains the non-zero flows for the BEA pairs. This file is the input into the subsequent generation of the BEA and PE pair growth index matrices. The second output file contains a revised set of shipment distribution coefficients corresponding to the matrix solution produced during the run. In initiating a run for the next time period, the system will automatically replace the base shipment coefficients with the revised set from the previous run. The third output file contains the set of changes between the initial solution and the solution after the automatic adjustment has been applied. The fourth output file is similar to the third file except that it contains the replacement values.

The system is designed to keep only the latest version of the output files for a given year. Thus if several successful runs were made for the same year, the newest file would automatically replace the existing file.

A-8. Printing of the
Second Solution Only

The Model normally prints out two solutions during a given run, an initial solution based on the input data, and a second solution based on applying the automatic adjustment step to the initial solution. If the printout of the first solution is not needed, it can be eliminated by specifying FS=NO in the run initiation statement.

A-9. System Error Messages

The system provides for a number of error checks in the specification of the input data. If an error is encountered, an error message will be printed out and the run terminated.

The following is a list of the current error checks:

- . if the year is correct;
- . if the commodity code is correct;
- . if the matrices are being solved in time order;
- . if the row and column BEAs specified in the manual adjustment file are correctly coded;
- . if the rows specified in the row freeze step are correctly coded.

B. Computer Procedure for Generating the
O-D PE Pair Growth Index Records

B-1. General Discussion

A computerized procedure has been developed to generate both BEA and PE growth index records for any commodity. The procedure is normally initiated after all of the O-D BEA flow matrices for the base year 1976 and the future years 1980, 1990, 2000, 2020 and 2040 have been finalized. The procedure produces a computer file containing the set of commodity growth index records for any BEA and PE pair with at least one non-zero flow between the period 1976 and 2040. The procedure is run for each commodity separately. The procedure can be also used after at least the 1976 and 1980 files have been generated to obtain a partial growth index record.

Input files to the procedure are (1) the individual O-D BEA pair flow files generated by the model and (2) the PE flow percentage distribution coefficients.

B-2. Flow Percentage Distribution Coefficient File

This section describes the procedures for coding the PE distribution coefficient and the preparation of the keypunch forms.

A record must be generated for each non-zero O-D PE pair within each non-zero BEA pair. The sum of the coefficients for all PE pairs within a given O-D BEA pair must be equal to 1.000.

For each PE pair record the following data are required (all values must be right-adjusted):

Col 1-3 :	3-digit number of origin BEA;
Col 4-6 :	3-digit number of designation BEA;
Col 7-10:	4-digit number of origin PE;
Col 11-14:	4-digit number of destination PE;
Col 15-16:	commodity group code;
Col 17-21:	decimal equivalent of the flow coefficient for the given PE pair. The decimal must be coded in the value;
Col 22-25:	year in which new flow percentage coefficient is to take affect;
Col 26-31:	new flow percentage coefficients;
Col 32-35:	year in which new flow percentage coefficient is to take affect;
Col 36-41:	new flow percentage coefficient.

The specification of two or more flow coefficients (Column 22-41) is optional. If column 22-25 is blank, the Model assumes that the first value applies from 1976 through 2040. If a year and a corresponding value are coded in column 22-25 and column 26-30, respectively, the Model will replace the original value with the new value starting with the given year. The new value will remain in effect through 2040 unless another year is subsequently specified (col. 32-35).

To create a PE coefficient file for a given commodity, type the following statements:

1. NEW, PECOF^{CG}
where CG is the commodity group code

2. the PE coefficient records

3. REPLACE, PECOFCG

B-3. Generation of the O-D
BEA-PE Pair Flow Files

As soon as the necessary input files for a commodity have been generated, the procedure can be executed. To initiate the procedure for a specific commodity group (e.g., 05), it is only necessary to type in the following statement:

-ORBCOMG(CG=05)

This statement causes the generation of the O-D BEA pair growth index file using the individual year Model-generated commodity flows. To list the BEA growth index file type:

OLD, BEAF05
LIST

In addition, a table containing the commodity tonnage values can be generated by typing the following:

-ORBPEAT(CG=05, OUTLOC=0)

To print out the table, type:

OLD, ORBRPT
LIST

After the BEA growth index file has been checked out for correctness and reasonability, the following is typed to generate the growth index records at the PE level:

-ORBPEI(CG=05)

To list the PE growth index file for the commodity, type:

OLD, PEF05
LIST

B-4. Computer Procedure for Generating
the Commodity BEA-PE Matrix Tables

A computerized procedure has been developed to facilitate the generation of hard-copies of the BEA-PE commodity tables, for any year from 1976 through 2040.

To produce a file containing the hard-copy matrices of the 15 BEA-PE commodity tables (contained in data file PEFFILE) plus the total for all commodities for a given year (e.g., 1985), it is only necessary to type the following statement:

```
-ORBTBQ(YEAR=1985, GT=1, DATA=PEFFILE)
```

Because of the volume of output, the tables are disposed to a high speed printer, which in the case of RRNA is the Washington, D.C. location of the CDC high-speed printer.

The procedure statement gives the user three options in regard to the individual and total tables. To request just the individual commodity tables set GT=0, for the individual plus total tables set GT=1, and for the total table only set GT=2.

The table generation program is set up to handle any subset of the records contained in PEFFILE. Thus, for example, the file PEF01, which contains the commodity 01 PE growth index records, can be used by typing DATA=PEF01 in the procedure statement. For this case GT would be set to 0 as a total table would be meaningless.

The table generation program requires two special input files referred to as ORIGIN and DESTIN. The file ORIGIN contains the set of BEA-PEs making up the origins of the commodity flow matrix while the file DESTIN contains the set of destination BEA-PEs. Both ORIGIN and DESTIN are generated from the growth index record file PEFFILE. For cost and operating efficiency reasons the table generation program was set up for a particular set of BEA-PE origins and destinations. For example, the set used for PEFFILE contains approximately 329 origins and 284 destinations.

If changes occur in traffic flow projections that result in new BEA-PEs being created or if, for operating efficiency reasons, it is desirable to work with a different size origin/destination matrix, then certain preliminary steps must be taken prior to running the table generation program. These steps involve generating new ORIGIN and DESTIN files, and secondly recompiling the table generating program based on the new matrix size.

To generate ORIGIN and DESTIN for running only the commodity 01 file, it is only necessary to type:

```
-RUNLK2(DATA=PEF01)
```

C. Procedure Files

C-1. -ORBODF (arguments)

1. Purpose: Used to generate a BEA flow matrix for a given commodity in a given year.

2. Procedure arguments:

YEAR= : year
CG= : commodity code
MIN= : manual intervention to be performed?
(Yes/No) (default is no)
MIRV= : the manual intervention value represents
a replacement value or a difference value
(VAL/DIFF) (default is DIFF)
MIFILE= : name of manual intervention file (default
is none)
FRZ= : certain rows to be frozen? (Yes/No) (de-
fault is no)
AU= : automatic adjustment to be performed?
(Yes/No) (default is yes)
OUT= : output files to be generated? (Yes/No)
(default is yes)
FS= : first solution to be printed out?
(Yes/No) (default is yes)

3. Procedure files used within ORBODF: ORBGET

4. Listing of procedure files:

- a. ORBODF

- (1) RETURN,TAPE6.
- (2) GET,ORBGET.
- (3) Q,ORBGET.BR;C/YEARX/YEAR/1; C/CGX/CG/2
- (4) CALL(ORBGET)
- (5) GET,TAPE1=MIFILE/NA.

- (6) IF(FILE(ORBODFB,AS)=0)GET,ORBODFB.
- (7) Q,TAPE7.BR;C/YEARX/YEAR;/C/CGX/CG/;
C/MINX/MIN;/C/AUX/AU/
- (8) Q,TAPE7.BRC;C/FRZX/FRZ;/C/OUTX/OUT/;
C/FSX/FS;/C/MIRVX/MIRV/
- (9) ORBODFB.
- (10) PRIMARY,TAPE6.
- (11) REPLACE,TAPE6=ORBTP6

Explanation:

- (1) clears the name TAPE6 from the local file directory;
- (2) makes the procedure file ORBGET a local file;
- (3) Q is an XEDIT command for in-line editing. Referring to file ORBGET, the string YEARX is to be replaced through the procedure arguments, and correspondingly CGX is to be replaced by the value of CG;
- (4) executes the procedure file ORBGET;
- (5) if MIFILE exists it will be made a local file called TAPE1;
- (6) makes ORBODFB, the primary object program for ORBMODL, a local file;
- (7/8) edits TAPE7 by replacing the values of YEARX, CGX, MINX, AUX, FRZX, OUTX, FSX and MIRVX with values supplied through the procedure arguments;
- (9) executes ORBODFB;
- (10) makes the output file, containing the hard-copy BEA matrices, the primary file. In this way, the matrix can be printed out simply by typing LIST.
- (11) saves the file containing the output report for subsequent printing.

b. ORBGET

- (1) GET,TAPE2=TSCCGX.
- (2) GET,TAPE3=SCGXYEARX.
- (3) GET,TAPE7=ORBOPT.

Explanation:

- (1) makes TSCCGX a local file called TAPE2
- (2) makes SCGXYEARX a local file called TAPE3
- (3) makes ORBOPT a local file called TAPE7

C-2. -ORBCOMG (arguments)

1. Purpose: Used to generate a BEA growth index record file for a given commodity.
2. Procedure arguments:
CG=: commodity code.
3. Procedure files used within ORBCOMG: ORBGET2
4. Listing of procedure files:

a. ORBCOMG

- (1) GET,ORBGET2
- (2) Q,ORBGET2.BR;C/CGX/CG/
- (3) CALL(ORBGET2)
- (4) GET,ORBIDXB.
- (5) ORBIDXB.
- (6) PURGE,CFLOW.

Explanation:

- (1) makes the procedure file ORBGET2 a local file;
- (2) edits ORBGET2. All occurrences of the string CGX are replaced by the value of CG which itself is set through the procedure arguments;
- (3) executes the procedure file ORBGET2;
- (4) makes the primary object file of fortran program ORBGIDX a local file;
- (5) executes ORBIDXB;
- (6) purges the file CFLOW.

b. ORBGET2

- (1) NEW,CFLOW
- (2) Q.BR;+I;99999
- (3) SAVE,CFLOW.

- (4) GET,CCGX1976,CCGX1980,CCGX1990,
CCGX2000,CCGX2020,CCGX2040/NA.
- (5) APPEND,CFLOW,CCGX1976,CCGX1980,CCGX1990,
CCGX2000,CCGX2020,CCGX2040/NA.
- (6) GET,CFLOW.
- (7) PACK,CFLOW.
- (8) RFL,50000.
- (9) ZORT,CFLOW,CFLOW,17,Z,A,C,1,7.
- (10) REDUCE.
- (11) REPLACE,CFLOW.
- (12) GET,TAPE1=CFLOW.

Explanation:

- (1) creates a new file called CFLOW;
- (2) inserts the value 99999 as the first record in the file CFLOW;
- (3) makes CFLOW a permanent file;
- (4) makes the 6 BEA commodity flow files, local files;
- (5) merges the 6 commodity files into the file CFLOW;
- (6) makes the expanded CFLOW file a local file;
- (7) removes the end of record marks associated with the merged commodity files;
- (8) increases the core available for sorting;
- (9) sorts the records in CFLOW;
- (10) eliminates unneeded core;
- (11) renames CFLOW as TAPE1.

C-3. -ORBPEI (arguments)

1. Purpose: Used to generate a PE growth index record file for a given commodity.
2. Procedure arguments: CG=: Commodity Code
3. Procedure files used within ORBPEI: ORBGET3, ORBGET4
4. Listing of procedure files:

a. ORBPEI

- (1) GET,ORBGET3.
- (2) Q,ORBGET3.BR;C/CGX/CG/*
- (3) CALL(ORBGET3)
- (4) GET,ORBPEIB.
- (5) ORBPEIB.
- (6) GET,ORBGET4.
- (7) Q,ORBGET4.BR;C/CGX/CG/*
- (8) CALL,ORBGET4.

Explanation:

- (1) makes the procedure file ORBGET3 a local file;
- (2) edits ORBGET3 by replacing all occurrences of CGX with the value of CG which itself is set through the procedure arguments;
- (3) executes the procedure file ORBGET3;
- (4) makes ORBPEIB, the binary object file of fortran program OBBPEGI, a local file;
- (5) executes ORBPEIB;
- (6) makes the procedure file ORBGET4 a local file;
- (7) edits ORBGET4 by replacing all occurrences of CGX with the value of CG;
- (8) executes the procedure file ORBGET4.

b. ORBGET3

- (1) PURGE,PEFCGX/NA.
- (2) RFL,50000.
- (3) GET,PECOFCGX.
- (4) ZORT,PECOFCGX,PECOFCGX,80,Z,A,C,1,6.
- (5) REDUCE.
- (6) REPLACE,PECOFCGX.
- (7) GET,TAPE1=BEAFCGX.
- (8) GET,TAPE2=PECOFCGX.

Explanation:

- (1) purges, the old growth index file PEFCGX;
- (2) increases the core size available for sorting;
- (3) makes the file PECOFCGX a local file;
- (4) sorts PECOFCGX;
- (5) eliminates unneeded core;
- (6) makes the local version of PECOFCGX the permanent version;
- (7) makes BEAFCGX a local file called TAPE1;
- (8) makes PECOFCGX a local file called TAPE2.

c. ORBGET4

- (1) RFL,50000.
- (2) GET,PEFCGX.
- (3) ZORT,PEFCGX,PEFCGX,80,Z,A,C,1,14.
- (4) REPLACE,PEFCGX.

Explanation:

- (1) increases the core size available for sorting;

- (2) makes the file PEFCGX a local file;
- (3) sorts PEFCGX;
- (4) makes the sorted local copy of PEFCGX the permanent version.

C-4. -RUNLK2 (arguments)

1. Purpose: Used to generate data files ORIGIN and DESTIN and to determine the array sizes to be set within the matrix print program TABLEQ2.
2. Procedure arguments:
DATA=: name of file containing PE growth index records.
3. Procedure files used within RUNLK2: TBQCMPL
4. Listing of procedure file:

a. RUNLK2

```
(1) GET,LOOKAT2.
(2) RFL,5000.
(3) GET,TAPE1=DATA/NA.
(4) IF(FILE(TAPE1,AS)=1)GOTO,3LN.
(5) ATTACH,TAPE1.
(6) COPY,DATA,TAPE1.
(7) 3LN,ZORT,TAPE1,TAPE1,80,Z,A,C,15,2,A,C,1,14.
(8) REDUCE.
(9) RETURN,TAPE2,LGO.
(10) FTN,I=LOOKAT2,L=0,TS,SEQ,GO,REW.
(11) RETURN,ORIGIN,DESTIN.
(12) RFL,65000.
(13) ZORT,TAPE2,TAPE2,80,Z,A,C,1,3,A,C,4,
    3,A,C,16,4.
(14) REWIND,TAPE2.
(15) REDUCE.
(16) COPYCF,TAPE2,ORIGIN,1,8,20.
(17) REWIND,ORIGIN,TAPE2.
(18) REPLACE,ORIGIN.
(19) Q,LOOKAT2,XC/ROWS=/COLS=/;XL/(I3,I4)
    /;XC/I3/7X,I3/
(20) REWIND,TAPE1.
(21) FTN,I=LOOKAT2,L=0,TS,SEQ,GO,REW.
(22) RFL,65000.
(23) ZORT,TAPE2,TAPE2,80,Z,A,C,1,3,A,C,4,
    3,A,C,16,4.
(24) REDUCE.
(25) REWIND,TAPE2.
(26) COPYCF,TAPE2,DESTIN,1,8,20.
```

(27) REWIND,DESTIN.
(28) REPLACE,DESTIN.
(29) REWIND,TAPE3.
(30) PACK,TAPE3.
(31) GBT,ORBRUNB.
(32) ORBRUNB.
(33) REPLACE,TAPE4=RUNOUT.
(34) CALL(TAPE4).

Explanation:

- (1) makes the fortran program LOOKAT2 a local file;
- (2) increases available core for sorting;
- (3) makes the growth index file DATA a local file called TAPE1 (applies only to indirect access files);
- (4) if the file TAPE1 exists as an indirect access file then execution of the procedure file skips to line 7;
- (5) if the input file DATA is not an indirect access file then gets it as a direct access file;
- (6) generates a local file copy of DATA called TAPE1;
- (7) sorts TAPE1 by commodity group and PE codes;
- (8) eliminates unneeded core;
- (9) clears the name TAPE2 and LGO from the local files;
- (10) executes the fortran program LOOKAT2;
- (11) clears the names ORIGIN and DESTIN from the local files;
- (12) increases available core size for sorting;

- (13) sorts TAPE2;
- (14) rewinds TAPE2;
- (15) eliminates unneeded core;
- (16) copies columns 8 through 20 of each record in TAPE2 to a new file, called ORIGIN;
- (17) rewinds TAPE2 and ORIGIN;
- (18) replaces the current permanent version of ORIGIN with the local file copy;
- (19) edits the fortran program LOOKAT2 by replacing the strings ROWS =, COLS =, and on the line containing (I3, I4) changing the string I3 to 7X, I3;
- (20) rewinds TAPE1;
- (21) reexecutes the program LOOKAT2;
- (22) increases the available core size for sorting;
- (23) sorts TAPE2;
- (24) eliminates unneeded core;
- (25) rewinds TAPE2;
- (26) copies columns 8 through 20 of each record in TAPE2 to a new file called DESTIN;
- (27) rewinds DESTIN;
- (28) replaces the current permanent version of DESTIN with the local file copy;
- (29) rewinds TAPE3 (outputs from program LOOKAT2);

- (30) eliminates end of record marks from
TAPE3;
- (31) makes the compiled binary object file (ORBRUNB)
of the fortran program ORBRUN a local file;
- (32) executes ORBRUNB;
- (33) saves the file (TAPE4) generated by ORBRUNB
as RUNOUT;
- (34) executes the fortran-generated procedure file
TAPE4 (see Section E. TBQCMPL).

C-5. -TBQCMPL (arguments)

1. Purpose: Used to generate a binary object file of the matrix print program TABLEQ2. It is generated automatically by RUNLK2 and executed in step 34 of RUNLK2 in the form CALL (TAPE4).
2. Procedure arguments:
ROWS = number of rows in matrix
COLS = number of columns in matrix
3. Procedure files used within TBQCMPL: none
4. Listing of procedure file:
 - a. TBQCMPL
 - (1) GET, TABLEQ2.
 - (2) Q, TABLEQ2.XC/*NROW/ROWS/*;XC/*NCOL/COLS/*
 - (3) RFL, 20000.
 - (4) FTN, I=TABLEQ2, L=0, B=TABLEQB.
 - (5) REPLACE, TABLEQB.

Explanation:

- (1) makes the fortran program TABLEQ2 a local file;
- (2) edits TABLEQ2, replacing all occurrences of *NROW and *NCOL with the values of ROWS and COLS which are set through the procedure arguments;
- (3) sets the field length at 20,000 octal;
- (4) compiles TABLEQ2;
- (5) makes the local compiled file TABLEQB the permanent version.

C-6. -ORBTBQ (arguments)

1. Purpose: Used to generate hard-copy of the O-D BEA-PE commodity matrices for any year.
2. Procedure arguments:
 - YEAR=: year
 - GT=: 0 if no grand total table desired,
1 if both individual and grand total
desired, 2 if only grand total desired;
 - DATA=: name of PE growth index file.
3. Procedure files used within ORBTBQ: none
4. Listing of procedure file:

a. ORBTBQ

```
(1) SET(R1=GT)
(2) GET,TAPE2=DATA/NA.
(3) IF(FILE(TAPE2,AS)=1)GOTO,3LN.
(4) ATTACH,DATA.
(5) COPY,DATA,TAPE2.
(6) 3LN,Q,TAPE2.BR;+IB;YEAR
(7) GET,ORBYRB.
(8) ORBYRB.
(9) GET,TABLEQB,TAPE4=ORIGIN,TAPE5=DESTIN.
(10) RETURN,TAPE2.
(11) RFL,50000.
(12) REDUCE.
(13) IF(R1=2)GOTO,2LN.
(14) TABLEQB.
(15) IF(R1=0)GOTO,1LN.
(16) REWIND,TAPE1,TAPE4,TAPE5.
(17) 2LN,TABLEQB.GRAND TOTAL
(18) 1LN,REWIND,TAPE2.
(19) PACK,TAPE2.
(20) DISPOSE,TAPE2=PRE.
```

Explanation:

- (1) sets R1 equal to the value of GT as set in the procedure argument;
- (2) makes the growth index file DATA a local file called TAPE2 (applies only to an indirect access files);

- (3) if the file TAPE1 exists as a local file then execution of the procedure file skips to line 5;
- (4/5) same as "2" but applies only to direct access files;
- (6) edits TAPE2 by adding as the first record the value of YEAR as specified through the procedure arguments;
- (7) makes the binary object file (ORBYRB) of fortran program ORBTBQY a local file;
- (8) executes ORBYRB;
- (9) makes the following files local: TABLEQB which is the binary object file for program TABLEQ2, ORIGIN renamed TAPE4, and DESTIN renamed TAPES;
- (10) clears the name TAPE2 from the local files;
- (11) increases core available for executing the program;
- (12) eliminates unnecessary core;
- (13) if R1(=GT) equals 2 only the grand total is generated, execution skips to statement 2LN;
- (14) executes TABLEQ2;
- (15) if R1(=GT) is equal to 0 the grand total table is not generated, execution skips to statement 1LN;
- (16) rewinds TAPE1, TAPE4 and TAPES;
- (17) reexecutes TABLEQ2 in order to generate a grand total table if called for in the run (GT = 1);

- (18) rewinds TAPE2;
- (19) removes all of records marks from TAPE2;
- (20) disposes TAPE2 to the printer.

D. Fortran Programs

D-1. ORBMODL

1. Purpose: Used to perform the calculations involved in generating a BEA flow matrix solution for a given commodity in a given year.
2. Name of the permanent binary object file: ORBODFB.
3. Associated procedure file: ORBODF.
4. Input files:
 - TAPE1(MIFILE): the manual intervention file;
 - TAPE2(TSCCG): the time series file containing the BEA shipments and receipts;
 - TAPE3(SYEARCG): the file containing the shipment distribution coefficients;
 - TAPE7(ORBOPT): a file which to indicate the user options selected. The values in the file are set through the procedure file ORBSUBM.
5. Output files:
 - TAPE4(CCGYEAR): contains the set of non-zero flow generated;
 - TAPE5(SCGYEAR+): contains the shipment distribution coefficients for use in the next time period;
 - TAPE6: contains the hard-copy of the O-D BEA flow matrix solution;
 - TAPE8(DCGYEAR): contains the system generated difference manual intervention file;
 - TAPE9(RCGYEAR): Contains the system generated replacement manual intervention file.

Note: TAPE4, TAPE5, TAPE8 and TAPE 9 are specified on the program statement, however, the subroutine PFSUB automatically makes a permanent copy of the files.

6. Listing of program and data files:

```

00100 PROGRAM BEAODF (INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,
00110+TAPE4,TAPE5,TAPE6,TAPE7,TAPE8,TAPE9)
00120C
00130C THE PURPOSE OF THIS PROGRAM IS TO GENERATE A MATHEMATICALLY CORRECT
00140C HEA O/D MATRIX SOLUTION.
00150C IT DOES THIS THROUGH A COMBINATION OF MANUAL AND AUTOMATIC ADJUSTMENTS
00160C MADE ON THE INPUT DATA.
00170C
00180 DIMENSION SHPTS(42),RPTS(42),SF(42),HF(42),KUIF(42),T(36,42)
00190+,TN(36,42),RUIF(42),DTU(42)
00200+,ITN(42),TOK(42),TNOK(42),RFF(42)
00210+,SYR(6),RYR(6),IHFA(42),JHEA(42)
00220+,JYFA(6),JEM(5),JNO(42),JTN(42),AVAIL(42)
00230 REWIND 1
00240 REWIND 2
00250 REWIND 3
00260 REWIND 7
00270 REWIND 4
00280 REWIND 5
00290 REWIND 6
00300 REWIND 8
00310 REWIND 9
00320 DATA JYEAR/1976,1980,1990,2000,2020,2040/
00330+,JNO/42/
00340 DO 41 J=1,42
00350 K1 JNO(J)=J
00360C
00370C THIS SECTION READS IN THE INPUT DATA
00380C
00390 READ(7,105) IYFA,ICOM,IYESMA,IYESAA,IYESFR,IYESOT,IYESFS,IYESMIR
00400 IF(IYESMA.EQ."IN")IYESMA="NO"
00410 IF(IYESAA.EQ."AL")IYESAA="YES"
00420 IF(IYESFR.EQ."FR7")IYESFR="NO"
00430 IF(IYESFS.EQ."FS")IYESFS="YES"
00440 IF(IYESOT.EQ."OUT")IYESOT="YES"
00450 IF(IYESMIR.EQ."IPV")IYESMIR="IFF"
00460 IPAGE=IPAGE+1
00470 WRITE(6,145) IPAGE
00480 WRITE(6,500) IYFA,ICOM,IYESMA,IYESMIR,IYESFR,IYESAA,IYESFS,IYESOT
00490 PRINT 500,IYFA,ICOM,IYESMA,IYESMIR,IYESFR,IYESAA,IYESFS,IYESOT
00500 DO 19 NYR=1,6
00510 IF(JYFA(NYR).EQ.IYFA)GOTO 21
00520 19 CONTINUE
00530 WRITE(6,610) IYFA
00540 PRINT 610,IYFA
00550 GOTO 97
00560 21 READ(2,100)NO,NO
00570 IF(NO.GT.JNO)GOTO 67
00580 IF(NO.LE.JNO)GOTO 68
00590 67 WRITE(6,*)" DIMENSION SIZE TOO SMALL"
00600 PRINT *, "DIMENSION SIZE TOO SMALL"
00610 GOTO 97
00620 68 DO 1,I=1,NO
00630 READ(2,101) IHEA(I),(SYR(J),J=1,6)
00640 1 SHPTS(I)=SYR(NYR)
00650 DO 2 I=1,NO
00660 READ(2,101) JHEA(I),(RYR(J),J=1,6)
00670 2 RPTS(I)=RYR(NYR)
00680 DO 4 I=1,NO
00690 READ(3,102) ICARD,ISEU, IREAX,ICG,(T(I,J),J=1,NO)
00700 IF(ICARD.EQ."01")GOTO 3
00710 IF(IHEAX.NE.IHEA(I))GOTO 3

```

BEST DOCUMENT AVAILABLE

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```

02580 IF(TN(I,J) .GT. 0.)TNOK(I)=TN(I,J)
02590 IF(T(I,J) .EQ. 0.)GOTO 74
02600 AVAIL(I)=SHPMTS(I) - DTD(I) - T(I,J)
02610 IF (AVAIL(I) .GT. .99)GOTO 61
02620 TNOK(I)=T(I,J)
02630 GOTO 62
02640 61 TOK(I)=AINT(T(I,J)*(1.+RFDIF)+.5)
02650 AVAIL(I)=SHPMTS(I)-DTD(I) - TOK(I)
02660 IF(AVAIL(I).GT.0.)GOTO 74
02670 TNOK(I)=TOK(I)+AVAIL(I)
02680 62 TOK(I)=0.
02690 TRDIST=TRDIST+TNOK(I)
02700 GOTO 82
02710 74 UNDIST=UNDIST+T(I,J)
02720 82 CONTINUE
02730 46 CONTINUE
02740 IF(UNDIST .GT. 0.)RFDIF=(RPTS(J) -TRDIST)/UNDIST - 1.0
02750 RFR0=0
02760 DO 59 I=1,N0
02770 IF(TOK(I) .GT. 0)GOTO 69
02780 TN(I,J)=TNOK(I)
02790 GOTO 41
02800 69 TN(I,J)=AINT(T(I,J)*(1.+RFDIF)+.5)
02810 41 RFR0=RFR0+TN(I,J)
02820 59 CONTINUE
02830 IF(RFR0 .EQ. RPTS(J))GOTO 49
02840 TMAX=0
02850 DO 44 I=1,N0
02860 AVAIL(I)=SHPMTS(I)-DTD(I)-TN(I,J)
02870 IF(TN(I,J) .LT. TMAX)GOTO 44
02880 IF(AVAIL(I) .LT. 1.)GOTO 44
02890 TMAX=TN(I,J)
02900 IMAXI=I
02910 44 CONTINUE
02920 TN(IMAXI,J)=TN(IMAXI,J)+(RPTS(J)-RFR0)
02930C
02940C THIS SECTION ADJUSTS THE COLS. NOT PRESENTLY NOR PREVIOUSLY SELECTED,
02950C TO MAINTAIN THE CONDITION THAT TOTAL ROW SHIPMENTS EQUAL TOTAL ROW FLOWS
02960C
02970 49 DO 50 I=1,N0
02980 IF(T(I,J) .EQ. 0.)GOTO 50
02990 DTD(I)=DTD(I)+TN(I,J)
03000 T(I,J)=0
03010 DSAF=0
03020 DO 52 JJ=1,N0
03030 DSAF=DSAF+T(I,JJ)
03040 52 CONTINUE
03050 SFDIF=0
03060 IF(DSAF .NE. 0) SFDIF=(SHPMTS(I)-DTD(I)-DSAF)/DSAF
03070 SCHG=0
03080 DO 53 JJ=1,N0
03090 IF(T(I,JJ) .EQ. 0)GOTO 53
03100 CHG=T(I,JJ)*SFDIF
03110 SCHG=SCHG+CHG
03120 T(I,JJ)=T(I,JJ)*(1.+SFDIF)
03130 53 CONTINUE
03140 50 CONTINUE
03150 DO 60 J=1,N0
03160 IF(RF(J) .EQ. RPTS(J)) GOTO 60
03170 RF(J)=0
03180 DO 65 I=1,N0
03190 65 RF(J)=RF(J) + T(I,J)+TN(I,J)

```

```

03820 WRITE(8,701) I,HEA(I)
03830 WRITE(9,701) I,HEA(I)
03840 1091 IJ=I*100 + J
03850 WRITE(8,702) IJ,JHEA(J),TN(I,J)
03860 IF(T(I,J).NE.0)WRITE(9,702) IJ,JHEA(J),T(I,J)
03870 IF(T(I,J).EQ.0)WRITE(9,704) IJ,JHEA(J)
03870 202 CONTINUE
03880 201 CONTINUE
03890 WRITE(9,703)
03900 ENCODE(10,196,ITAPE9)ICOM,IYEAR
03910 ENDFILE 9
03920 CALL PFSUB(7HREPLACE,5HTAPE9,ITAPE9,0,0,0,0,UCW,IES,IEM)
03930 IF(IES.EQ.0)GOTO 1090
03940 PRINT *,IEM
03950 1090 CONTINUE
03960 WRITE(8,703)
03970 ENCODE(10,195,ITAPE8) ICOM,IYEAR
03980 ENDFILE 8
03990 CALL PFSUB(7HREPLACE,5HTAPE8,ITAPE8,0,0,0,0,UCW,IES,IEM)
04000 IF(IES.EQ. 0)GOTO 97
04010 PRINT *,IEM
04020 GOTO 97
04030 100 FORMAT(1X,2I2)
04040 101 FORMAT(3X,A3,2X,6F10.0)
04050 102 FORMAT(2A2,A3,A2,1X,14F5.3,2(/,10X,14F5.3))
04060 105 FORMAT(I4,7(/A4))
04070 110 FORMAT(/,22X,14(6X,I2))
04080 120 FORMAT(1X,A5)
04090 125 FORMAT(A3)
04100 146 FORMAT(" 0-D HEA MATRIX FOR COMMODITY ",A2," AND YEAR ",I4 )
04110 130 FORMAT( 5X,"ORIGIN/DEST: TOTAL",14(5X,A3),/)
04120 140 FORMAT(/,6X,"SHPTS/RPTS:",15F8.0,/)
04130 145 FORMAT("1 PAGE:",I2,/)
04140 150 FORMAT(1X,I2,1X,A3,1X,F8.0,1X,15F8.0)
04150 160 FORMAT(/,4X,"TOT ",F8.0,1X,15F8.0,/)
04160 170 FORMAT(/," ADJUSTMENT REQ.",9X,14F8.0,/,2(26X,14F8.0/))
04170 172 FORMAT(I4,4X,14F8.0)
04180 180 FORMAT(1HC,A2,I4.4)
04190 190 FORMAT(1HS,A2,I4.4)
04200 195 FORMAT(1HD,A2,I4.4)
04210 196 FORMAT(1HR,A2,I4.4)
04220 200 FORMAT(" ")
04230 500 FORMAT( // " YEAR: ",I4,4X,"COMMODITY GROUP: ",A2,/, " MANUAL ADJ.: "
04240+A4,4X,"MANUAL ADJ. TYPE: ",A4
04250+ ,/, " FREEZE ROW: ",A3,4X,"AUTOMATIC ADJ.: ",A3,/, " PRINT FIRST"
04260+" SOLUTION: ",A3,4X,"GENERATE OUTPUT FILES: ",A3, )
04270 510 FORMAT(" ERROR FOUND IN DATA FILE S",A2,I4," AT LINE: "
04280+A2,A2,A3,A2,". CARD MAY BE OUT OF ORDER OR HEA NO. MAY NOT".
04290+" BE CORRECT")
04300 513 FORMAT(A5,A3,2X,F8.1)
04310 512 FORMAT(" ERROR IN MANUAL ADJUSTMENT STEP")
04320 514 FORMAT(" NO ROW FOUND WITH NO.: ",A3,
04330+" . CHECK FILE M",A2,I4," LINE: ",A5)
04340 515 FORMAT(" NO COL FOUND WITH NO.: ",A3,
04350+" . CHECK FILE M",A2,I4," LINE: ",A5)
04360 516 FORMAT(" ERROR IN ROW FREEZE STEP")
04370 518 FORMAT(" MANUAL INTERVENTION REQUIRED FOR HEA COL ",A3)
04380 600 FORMAT(2A3,I1,A2,F8.0)
04390 601 FORMAT("01",I2,A3,A2,I1,14F5.3/"02",8X,14F5.3/"03",8X,14F5.3)
04400 610 FORMAT(" PROJECTION YEAR",I6," IS NOT A VALID YEAR")
04410 700 FORMAT(3(10X,14F5.3/))
04420 701 FORMAT(I2,2,"00",1X,A3)

```

```

00720 DO 5 J=1,ND
00730 5 T(I,J)=AINT(SHPMTS(I)*T(I,J)+.5)
00740 4 CONTINUE
00750 GOTO 80
00760 3 CONTINUE
00770 PRINT 510,ICOM,IYEAR,ICARD,ISEQ,IHEAX,ICG
00780 WRITE (6,510)ICOM,IYEAR,ICARD,ISEQ,IHEAX,ICG
00790 GOTO 97
00800C
00810C THIS SECTION ALLOWS FOR MANUAL ADJUSTMENTS TO BE MADE TO THE INPUT
00820C SHIPMENT COEFFICIENTS T(I,J)
00830C
00840 80 IF(IYESMA .EQ. "NO")GOTO 7
00850 8 READ(1,513) ICARD,IHEAX
00860 IF(IHEAX .EQ. "END")GOTO 6
00870 DO 11 I=1,40
00880 IF(IHEA(I) .NE. IHEAX)GOTO 11
00890 GOTO 12
00900 11 CONTINUE
00910 WRITE(6,512)
00920 PRINT 512
00930 WRITE(6,514)IHEAX,ICOM,IYEAR,ICARD
00940 PRINT 514,IHEAX,ICOM,IYEAR,ICARD
00950 GOTO 97
00960 12 READ(1,513) ICARD,JHEAX,TDIFF
00970 IF(TDIFF .EQ. 0)GOTO 9
00980 DO 13 J=1,ND
00990 IF(JHEA(J) .NE. JHEAX)GOTO 13
01000 GOTO 18
01010 13 CONTINUE
01020 WRITE(6,512)
01030 PRINT 512
01040 PRINT 515,JHEAX,ICOM,IYEAR,ICARD
01050 WRITE(6,514) JHEAX,ICOM,IYEAR,ICARD
01060 GOTO 97
01070 18 IF(IYESMIR .EQ. "DIFF")T(I,J)=T(I,J)+TDIFF
01080 IF(IYESMIR .EQ. "VAL")T(I,J)=AINT(TDIFF)
01090 GOTO 12
01100 9 BACKSPACE 1
01110 GOTO 8
01120 6 CONTINUE
01130C
01140C THIS SECTION COMPUTES MATRIX ROW AND COL TOTALS AND THE COL ADJUSTMENT
01150C VALUES NECESSARY TO GENERATE A CORRECT SOLUTION.
01160C
01170 7 IPASS=IPASS+1
01180 RFT=0
01190 RT=0
01200 ST=0
01210 DO 20 J=1,ND
01220 RT=RT+RPTS(J)
01230 RF(J)=0
01240 DO 15 I=1,40
01250 RFT=RFT+T(I,J)
01260 15 RF(J)=RF(J)+T(I,J)
01270 RDIF(J)=RPTS(J)-RF(J)
01280 20 CONTINUE
01290 DO 10 I=1,NO
01300 ST=ST+SHPMTS(I)
01310 SF(I)=0
01320 DO 10 J=1,ND
01330 10 SF(I)=SF(I)+T(I,J)

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```

01340 IF(IPASS .GT. 1)GOTO 22
01350 DO 87 I=1,ND
01360 IF(SF(I) .EQ. SHPMTS(I))GOTO 87
01370 IF(SF(I) .EQ. 0.)GOTO 87
01380 SDIF=SHPMTS(I) - SF(I)
01390 SWDIF=1
01400 IF(SDIF .LT. 0) SWDIF=-1
01410 DO 83 J=1,ND
01420 IF(RDIF(J) .EQ. 0.)GOTO 83
01430 IF(T(I,J) .EQ. 0.)GOTO 83
01440 T(I,J)=T(I,J)+SWDIF
01450 RF(J)=RF(J)+SDIF
01460 RFT=RFT+SWDIF
01470 RDIF(J)=RPTS(J)-RF(J)
01480 SF(I)=SF(I) + SWDIF
01490 IF(SF(I) .EQ. SHPMTS(I))GOTO 87
01500 83 CONTINUE
01510 87 CONTINUE
01520 DO 17 J=1,ND
01530 IF(RDIF(J) .NE. 0)GOTO 17
01540 DO 15 I=1,ND
01550 15 DT0(I)=DT0(I)+T(I,J)
01560 17 CONTINUE
01570C
01580C THIS SECTION PRINTS OUT THE MATRIX SOLUTION
01590C
01600 22 CONTINUE
01610 IF(IYESFS .NE. "YES")GOTO 88
01620 PRINT *, "MATRIX SOLUTION GENERATED"
01630 J1=1
01640 J2=ND
01650 IF(ND.GT.14)J2=14
01660 ICONT=" "
01670 IPART=1
01680 92 IPAGE=IPAGE+1
01690 IPART=IPART+1
01700 WRITE(6,145) IPAGE
01710 IF(IPASS .EQ. 1)WRITE(6,*) "FIRST SOLUTION"
01720 IF(IPASS .GT. 1)WRITE(6,*) "SECOND SOLUTION"
01730 WRITE(6,146) ICOM,IYEAH
01740 WRITE(6,120) ICONT
01750 WRITE(6,110) (JNO(J),J=J1,J2)
01760 WRITE(6,130) (JREA(J),J=J1,J2)
01770 WRITE(6,140) RT, (RPTS(J),J=J1,J2)
01780 WRITE(6,200)
01790 DO 30 I=1,ND
01800 30 WRITE(6,150) I,IREA(I),SHPMTS(I),SF(I), (T(I,J),J=J1,J2)
01810 WRITE(6,160) ST,RFT, (RF(J),J=J1,J2)
01820 WRITE(6,170) (RDIF(J),J=J1,J2)
01830 ICONT="CONT'D"
01840 J1=J1+14
01850 J2=ND
01860 IF(IPART .EQ. 2 .AND. ND .GT. 28)J2=28
01870 IF(IPART .EQ. 3 .AND. ND .GT. 28)J2=ND
01880 IF(ND .GE. J1)GOTO 92
01890C
01900C THIS SECTION ALLOWS FOR AN AUTOMATIC MATRIX SOLUTION BASED ON PROPORTIONAL
01910C ADJUSTMENT.
01920C AS A FIRST STEP, ANY OF THE MATRIX ROWS CAN BE FROZED WITH THEIR
01930C CURRENT VALUES.
01940C
01950 88 IYESFS="YES"

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01960 IF(IYESAA .EQ. "NO ")GOTO 90
01970 IYFSAA="NO "
01980 IF(IYESFR .NE. "YES")GOTO 25
01990 26 READ(1,513) ICARD,IREAX
02000 36 IF(IREAX .EQ. "END")GOTO 25
02010 DO 28 I=1,NO
02020 IF(IREA(I) .NE. IREAX)GOTO 28
02030 GOTO 29
02040 28 CONTINUE
02050 WRITE(6,516)
02060 PRINT 516
02070 WRITE(6,514) IREAX,ICOM,IYEAR,ICARD
02080 PRINT 514,IREAX,ICOM,IYEAR,ICARD
02090 GOTO 97
02100 29 CONTINUE
02110 DO 27 J=1,ND
02120 TN(I,J)=T(I,J)
02130 RFF(J)=RFF(J)+T(I,J)
02140 T(I,J)=0
02150 27 CONTINUE
02160 GOTO 26
02170 25 CONTINUE
02180C
02190C THIS SECTION FREEZES ALL MATRIX COLS IN WHICH THE COL ADJUSTMENT
02200C REQUIRED, PRIOR TO AUTOMATIC ADJUSTMENT, IS ALREADY ZERO.
02210C
02220 DO 35 J=1,ND
02230 IF(RDIF(J) .NE. 0)GOTO 35
02240 DO 40 I=1,NO
02250 IF(T(I,J) .EQ. 0.)GOTO 40
02260 TN(I,J)=T(I,J)
02270 T(I,J)=0
02280 40 CONTINUE
02290 RF(J)=RPTS(J)
02300 35 CONTINUE
02310C
02320C THIS SECTION SELECTS A COL FOR ADJUSTMENT ON THE BASIS OF THE SMALLEST
02330C ABSOLUTE NON-ZERO DIFFERENCE BETWEEN TOTAL COL RECEIPTS AND FLOWS.
02340C
02350 37 JMIN=0
02360 ICOL=ICOL +1
02370 IF(ICOL .GT. ND)GOTO 70
02380 RMIN=99999
02390 DO 45 J=1,ND
02400 RDIFM(J)=ABS(RDIF(J))
02410 IF(RDIFM(J) .EQ. 0)GOTO 45
02420 IF(RMIN .LE. RDIFM(J))GOTO 45
02430 JMIN=J
02440 RMIN=RDIFM(J)
02450 45 CONTINUE
02460 IF(JMIN .EQ. 0)GOTO 70
02470 24 J=JMIN
02480C
02490C THIS SECTION CORRECTS THE MATRIX ROW VALUES FOR THE COL SELECTED.
02500C
02510 TRDIST=0
02520 UNDIST=0
02530 RFDIF=0
02540 IF(ABS(RF(J)) .GE. 1)RFDIF=RDIF(J)/RF(J)
02550 DO 46 I=1,NO
02560 TOK(I)=0
02570 TNOK(I)=0

```

```
03200 RDIF(J)=RPTS(J)-RF(J)
03210 IF(ABS(RDIF(J)) .LT. 1.)RDIF(J)=0.
03220 GO CONTINUE
03230 GOTO 37
03240C
03250C THIS SECTION SETS UP THE CORRECTED MATRIX FOR PRINTING OUT
03260C
03270 70 CONTINUE
03280 DO 72 I=1,N0
03290 DO 71 J=1,N0
03300 IF(TN(I,J) .GT. 0.)GOTO 75
03310 IF(T(I,J) .GT. .6)T(I,J)=AINT(T(I,J)+.5)
03320 GOTO 71
03330 75 T(I,J)=TN(I,J)
03340 71 CONTINUE
03350 72 CONTINUE
03360 GOTO 7
03370 90 CONTINUE
03380C
03390C THIS SECTION GENERATES, BASED ON THE CORRECTED MATRIX, A FILE OF
03400C SHIPMENT COEFFICIENTS AND A FILE OF MEA U/D FLOW.
03410C
03420 IF(IYESOT .NE. "YES")GOTO 97
03430 DO 98 I=1,N0
03440 IF(SF(I) .EQ. 0)GOTO 98
03450 TMAX=0
03460 RFRO=0
03470 DO 96 J=1,N0
03480 IF(T(I,J) .LT. 1.)GOTO 96
03490 TN(I,J)=AINT((T(I,J)/SF(I))*1000. +.5)
03500 IF(TN(I,J) .LT. TMAX)GOTO 77
03510 TMAX=TN(I,J)
03520 TMAXJ=J
03530 77 TN(I,J)=TN(I,J)/1000.
03540 RFRO=RFRO+TN(I,J)
03550 WRITE(4,600)INEA(I),JNEA(J),NYR,ICOM,T(I,J)
03560 96 CONTINUE
03570 IF(RFRO .EQ. 1.0)GOTO 98
03580 TN(I,TMAXJ)=TN(I,TMAXJ)+1.0-RFRO
03590 98 CONTINUE
03600 ENCODE(10,180,ITAPE4)ICOM,IYEAR
03610 ENDFILE 4
03620 CALL PFSUB(7HREPLACE,5HTAPE4,ITAPE4,0,0,0,0,UCW,IES,IEM)
03630 IF(IES.EQ.0)GO TO 95
03640 PRINT *,IEM
03650 95 IF(NYR .GE. 6)GOTO 205
03660 DO 93 I=1,N0
03670 93 WRITE(5,601)I,INEA(I),ICOM,NYR,(TN(I,J),J=1,N0)
03680 ENCODE(10,190,ITAPE5)ICOM,JYEAR(NYR+1)
03690 ENDFILE 5
03700 CALL PFSUB(7HREPLACE,5HTAPE5,ITAPE5,0,0,0,0,UCW,IES,IEM)
03710 IF(IES.EQ.0)GOTO 205
03720 PRINT *,IEM
03730 205 REWIND 3
03740 DO 201 I=1,N0
03750 HEAD(3,700) (TN(I,J),J=1,N0)
03760 ITEST=0
03770 DO 202 J=1,N0
03780 TN(I,J)=T(I,J)-AINT(SHPMTS(I)*TN(I,J) + .5)
03790 IF(ABS(TN(I,J)) .LT. 1)GOTO 202
03800 ITEST=ITEST+1
03810 IF(ITEST.NE.1)GOTO 1091
```

```
04430 702 FORMAT(I4.4,1X,A3,2X,F8.0)
04440 703 FORMAT("100000END")
4442 704 FORMAT(I4.4,1X,A3,2X,"      0.1")
04450 97 REWIND 4
04460 REWIND 5
04470 REWIND 1
04480 REWIND 2
04490 REWIND 3
04500 REWIND 6
04510 REWIND 7
04520 REWIND 8
04530 REWIND 9
04540 STOP
04550 END
```

BEST DOCUMENT AVAILABLE

-87--

Input File

Tape 1 = MIFILE = M101990

0100 047	
0102 047	-1.
0103 048	-229.
0111 114	60.
0114 143	170.
0200 048	
0203 048	-134.
0204 049	142.
0211 114	-3.
0214 143	-5.
0300 050	
0303 048	36.
0310 066	-36.
0700 115	
0701 046	-29.
0703 048	64.
0710 066	-35.
0800 117	
0808 055	3.
0810 066	-3.
1000 138	
1009 062	-5.
1010 066	5.
10000END	

Input File

Tape 2 = TSC10

X1219						
S0104710	3362	3298	4214	4907	6388	7597
S0204810	970	951	1215	1416	1843	2192
S0305010	385	468	872	1267	2197	3008
S0405410	20	23	29	35	59	82
S0506210	203	228	293	349	518	655
S0610710	27					
S07115	36	57	124	232	364	400
S0811710	17	11	25	31	52	71
S0913510	57	43	90	111	186	254
S1013810	18	14	28	33	54	72
S1104010	0	0	0	0	0	0
S1213710	0	0	0	0	0	0
R0104610	36	41	60	75	94	105
R0204710	1428	1401	1790	2084	2713	3227
R0304810	2941	2885	3685	4293	5589	6646
R0404910	264	329	562	769	1383	1960
R0505010						
R0605210						
R0705410						
R0805510	3	0	3	4	6	8
R0906210	6	7	9	10	15	19
R1006610	83	96	131	161	271	370
R1111410	21	21	84	151	371	369
R1211510						
R1313810	250	251	322	384	577	737
R1414310	63	62	244	450	642	890
R1501010	0	0	0	0	0	0
R1607710	0	0	0	0	0	0
R1707810	0	0	0	0	0	0
R1807910	0	0	0	0	0	0
R1913710	0	0	0	0	0	0

BEST DOCUMENT AVAILABLE

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Input File

Tape 3 = S101990

[illegible]

BEST DOCUMENT AVAILABLE

-90-

Input File

Tape 7 = ORBOPT

YEARX
CGX
MINX
AUX
FRZX
OUTX
FSX

BEST DOCUMENT AVAILABLE

-91-

Output File

Tape 4 = C101990

047047310	1790.
047048310	2194.
047114310	60.
047143310	170.
048048310	555.
048049310	562.
048114310	24.
048143310	74.
050048310	872.
054138310	29.
062138310	293.
115046310	60.
115048310	64.
117055310	3.
117066310	22.
135066310	90.
138062310	9.
138066310	19.

BEST DOCUMENT AVAILABLE

-92-

Output File

Tape 5 = S102000

[illegible]

Output File

Tape 8 = D101990

0100 047	
0102 047	-1.
0103 048	-229.
0111 114	60.
0114 143	170.
0200 048	
0203 048	-134.
0204 049	142.
0211 114	-3.
0214 143	-5.
0300 050	
0303 048	36.
0310 066	-36.
0700 115	
0701 046	-29.
0703 048	64.
0710 066	-35.
0800 117	
0808 055	3.
0810 066	-3.
1000 138	
1009 062	-5.
1010 066	5.
10000END	

D-2. ORBGIDX

1. Purpose: Used to generate a BEA growth index record file for a given commodity.
2. Name of the permanent binary object file: ORBIDXB.
3. Associated procedure file: ORBCOMG.
4. Input files:

TAPE1(CFLOW): is the file containing the non-zero flows for a commodity for the years 1976, 1980, 1990, 2000, 2020 and 2040. The file is automatically generated through the procedure file ORBGET2.

5. Output files:

TAPE3(BEAF CG): contains the BEA growth index records for the commodity.

Note: the subroutine PFSUB automatically creates a permanent copy of BEAF CG.

6. Listing of program and data files:

PROGRAM ORBGIDX

```
00100 PROGRAM BEAINDX(INPUT,OUTPUT,TAPE1,TAPE3)
00110 DIMENSION VAL(6),INDEX(6),IEM(5)
115 DATA VAL/6*0./
00120 REWIND 1
00130 REWIND 3
140 READ(1,102)JBEA,ICOM
00150 BACKSPACE 1
160 1 READ(1,100) IBEA,NYR,IV
180 IF(EOF(1)) 90,2
00200 2 IF(IBEAN.E. JBEA)GOTO 7
00220 4 IBEAX=IBEAN
00230 VAL(NYR)=IV
00240 GOTO 1
00250 7 JBEA=IBEAN
00270 DO 10 J=1,6
00280 IF(VAL(J) .GT. 0.)GOTO 12
00290 10 CONTINUE
00300 12 DO 20 K=1,6
00310 INDEX(K)=(VAL(K)*1000.)/VAL(J) +.5
00320 IF(INDEX(K) .GT. 100000)GOTO 50
00330 20 CONTINUE
00340 IVAL=VAL(J)
00350 WRITE(3,101) IBEAX,ICOM,IVAL,(INDEX(K),K=1,6)
00380 DO 60 I=1,6
00390 60 VAL(I)=0.
00400 GOTO 4
00410 50 J=J+1
00420 IF(VAL(J) .GT. 0)GOTO 12
425 GOTO 50
430 90 CONTINUE
431 ENCODE(10,105,ITAPE3)ICOM
432 ENDFILE 3
433 CALL PFSUB(7HREPLACE,5HTAPE3,ITAPE3,0,0,0,0,UCW,IES,IEM)
434 IF(IES.EQ.0)GOTO 95
435 PRINT *,IEM
490 95 REWIND 3
00500 REWIND 1
00510 STOP
520 100 FORMAT(A6,I1,2X,I7)
00530 101 FORMAT(A6,4X,A2,I7,5I7)
540 102 FORMAT(A6,1X,A2)
541 105 FORMAT(4HBEAF,A2)
00550 END
```


Output File

Tape 3 = BEAF

047047	10	1428	1000	981	1254	1459	1900	2260
047048	10	1934	1000	981	1134	1222	1201	1243
047049	10	553	0	0	0	0	1000	1857
047114	10	60	0	0	1000	1833	5000	4333
047143	10	170	0	0	1000	2059	2941	4000
048048	10	622	1000	867	892	814	1286	1511
048049	10	264	1000	1246	2129	2913	3144	3534
048114	10	21	1000	1000	1143	1952	3381	5190
048143	10	63	1000	984	1175	1587	2254	3333
050048	10	385	1000	1166	2265	3291	5706	7813
050066	10	19	0	1000	0	0	0	0
054138	10	20	1000	1150	1450	1750	2950	4100
062138	10	203	1000	1123	1443	1719	2552	3227
107138	10	27	1000	0	0	0	0	0
115046	10	36	1000	1139	1667	2083	2611	2917
115048	10	64	0	0	1000	2453	4219	4609
115066	10	16	0	1000	0	0	0	0
117055	10	3	1000	0	1000	1333	2000	2667
117066	10	14	1000	786	1571	1929	3286	4500
135066	10	57	1000	754	1579	1947	3263	4456
138062	10	6	1000	1167	1500	1667	2500	3167
138066	10	12	1000	583	1583	1917	3250	4417

D-3. ORBPEGI

1. Purpose: Used to generate a PE growth index record file for a given commodity.
2. Name of the permanent binary object file: ORBPEIB.
3. Associated procedure file: ORBPEI.

4. Input files:

TAPE1(BEAFCG): the file containing the BEA growth index records.

TAPE2(PECOFCG): the file containing the PE distribution coefficients.

5. Output files:

TAPE3(PEFCG): contains the PE growth index records.

Note: the subroutine PFSUB automatically creates a permanent copy of PEFCG.

6. Listing of the program and data files:

PROGRAM FILE: ORBPEGI

30/02/20. 12.03.55.
PROGRAM ORBPEGI

```
00100 PROGRAM ORBPEGI (INPUT, OUTPUT, TAPE1, TAPE2, TAPE3, TAPE4, TAPE5)
00110 DIMENSION INDEX(6), JYEAR(6), IYEAR(5), PCTN(5), VALX(6), KINDEX(6)
00120+, LBEA(2), IEM(5), J5(6)
00130 DATA JYEAR/1976, 1980, 1990, 2000, 2020, 2040/
00140 REWIND 1
00150 REWIND 2
00160 REWIND 3
00170 REWIND 4
00180 2 READ(1, 100) IBEA, ICDM, IVAL, (INDEX(K), K=1, 6)
00190 IF (EOF(1)) > 90, 3
00200 3 IF (IPASS.EQ. 1) GOTO 6
210 5 READ(2, 101) JBEA, JPE, JCDM, PCT, IY
00220 IF (EOF(2)) > 90, 6
221 6 CONTINUE
222 IF (IY.EQ. " ") GOTO 11
223 BACKSPACE 2
224 READ(2, 108) PCT, (IYEAR(K), PCTN(K), K=1, 2)
225 11 CONTINUE
232 IF (JBEA.GE. "000000".AND. JBEA.LE. "999999") GOTO 9
234 WRITE(3, *) "BAD DATA IN PEOF FILE.SEE LINE CONTAINING: ", JBEA
236 GOTO 94
238 9 CONTINUE
00240 IF (JBEA.EQ. IBEA) GOTO 10
00250 IF (JBEA.GT. IBEA) GOTO 7
00260 GOTO 20
00270 7 IPASS=1
00280 GOTO 2
00290 10 IF (IYEAR(1).GT. 1976) GOTO 50
00300 JVAL=IVAL+PCT+.5
00310 WRITE(5, 102) JBEA, JPE, JCDM, JVAL, (INDEX(K), K=1, 6)
00320 GOTO 5
00330 20 WRITE(4, 103) JBEA, JPE
00340 PRINT 103, JBEA, JPE
00350 GOTO 5
00360 50 K=1
00370 DO 60 J=1, 6
00380 IF (IYEAR(K).GT. JYEAR(J)) GOTO 58
00390 PCT=PCTN(K)
00400 IF (IYEAR(K+1).NE. 0) K=K+1
410 58 VALX(J) = IVAL+INDEX(J)+PCT/1000.
00420 60 CONTINUE
00430 J=0
00440 70 J=J+1
00450 IF (VALX(J).GT. 0) GOTO 80
00460 GOTO 70
00470 80 DO 85 K=1, 6
480 KINDEX(K)=VALX(K)+1000/VALX(J)+.5
00490 IF (KINDEX(K).GT. 100000) GOTO 70
00500 85 CONTINUE
510 JVALX=VALX(J)+.5
00520 WRITE(5, 102) JBEA, JPE, JCDM, JVALX, (KINDEX(K), K=1, 6)
535 IYEAR(1)=0
99530 GOTO 5
```

ORBPEGI (Continued)

```
00540 90 REWIND 5
00550 91 READ(5,105) LBER(1),LBER(2),J3,J4,(J5(I),I=1,6)
560 IF(EOF(5)) 94,92
562 92 DO 96 K=1,2
563 IF(LBER(K).LT."900") GOTO 96
564 IF(LBER(K).EQ."914") LBER(K)="114"
565 IF(LBER(K).EQ."946") LBER(K)="046"
566 IF(LBER(K).EQ."915") LBER(K)="115"
567 96 CONTINUE
00570 WRITE(3,107) LBER(1),J3,LBER(2),J4,(J5(I),I=1,6)
00580 GOTO 91
00590 94 REWIND 5
00610 REWIND 1
00620 REWIND 2
00630 ENCODE(10,105,ITAPE3) ICDM
00640 ENDFILE 3
00650 CALL PFSUB(7HREPLACE,5HTAPE3,ITAPE3,0,0,0,0,UCW,IES,IEM)
00660 IF(IES.EQ.0) GOTO 95
00670 PRINT *,IEM
00680 95 REWIND 3
00690 STOP
00700 100 FORMAT(A6,4X,A2,I7,6I7)
701 101 FORMAT(A6,A8,A2,F6.4,A1)
00720 102 FORMAT(A6,A8,A2,I7,6I7)
00730 103 FORMAT(" NO NON ZERO BEA PAIR EXISTS FOR PE PAIR ",A6,4X,A8)
00740 105 FORMAT(3HPEF,A2)
00750 106 FORMAT(2A3,2A4,6A10)
00760 107 FORMAT(2(A3,A4),6A10)
762 108 FORMAT(16X,F5.4,2(I4,F6.4))
00770 END
```

BEST DOCUMENT AVAILABLE

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Input File

Tape 2 = PECCFEG

04704713201320101.000
04704813301355101.000
04704913301320101.000
04711413300302101.00
04714313202740101.00
0480481335135510.1222
0480481355135510.4212
0480481360135510.4566
04804913201320101.000
0481141355011010.4286
0481141355030210.5714
04814313552740101.000
05004814001355101.000
05006614000610101.000
0541380234040510.25
0541380234041010.75
0621380238040510.8473
0621380238041010.1527
10713802380410101.000
1150460204048510.7778
1150460206048510.2222
11504802041355101.000
11506602040700101.000
11705515150216101.000
11706615200700101.000
1350662S00071510.2105
1350662S00072510.7895
13806204050238101.000
13806604150610101.000

BEST DOCUMENT AVAILABLE

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Output File

Tape 3 = PEFCG

0471320047132010	1428	1000	981	1254	1459	1900	2260
0471330048135510	1934	1000	981	1134	1222	1201	1243
0471330049132010	553	0	0	0	0	1000	1857
0471330114030210	60	0	0	1000	1833	5000	4333
0471320143274010	170	0	0	1000	2059	2941	4000
0481335048135510	76	1000	867	892	814	1286	1511
0481355048135510	262	1000	867	892	814	1286	1511
0481360048135510	284	1000	867	892	814	1286	1511
0481320049132010	264	1000	1246	2129	2913	3144	3534
0481355114011010	9	1000	1000	1143	1952	3381	5190
0481355114030210	12	1000	1000	1143	1952	3381	5190
0481355143274010	63	1000	984	1175	1587	2254	3333
0501400048135510	385	1000	1166	2265	3291	5706	7913
0501400066061010	19	0	1000	0	0	0	0
0540234138040510	5	1000	1150	1450	1750	2950	4100
0540234138041010	15	1000	1150	1450	1750	2950	4100
0620238138040510	172	1000	1123	1443	1719	2552	3227
0620238138041010	31	1000	1123	1443	1719	2552	3227
1070238138041010	27	1000	0	0	0	0	0
1150204046048510	28	1000	1139	1667	2083	2611	2917
1150206046048510	8	1000	1139	1667	2083	2611	2917
1150204048135510	64	0	0	1000	2453	4219	4609
1150204066070010	16	0	1000	0	0	0	0
1171515055021610	3	1000	0	1000	1333	2000	2667
1171520066070010	14	1000	786	1571	1929	3286	4500
1352800066071510	12	1000	754	1579	1947	3263	4456
1352800066072510	45	1000	754	1579	1947	3263	4456
1380405062023810	6	1000	1167	1500	1667	2500	3167
1380415066061010	12	1000	583	1583	1917	3250	4417

BEST DOCUMENT AVAILABLE

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D-4. LOOKAT2

1. Purpose: Used to generate the files ORIGIN and DESTIN and to calculate the size of the Table Q array.
2. Name of the permanent binary object file: none.
3. Associated procedure file: RUNLK2.
4. Input files:

TAPE1(DATA): the file containing the
PE growth index records.
5. Output files:

TAPE2 (ORIGIN and DESTIN): ORIGIN contains the set of
BEA and PEs making up the
matrix rows while DESTIN con-
tain the set of column
BEA/PEs.

TAPE3: An intermediate file containing
the count of the number of
matrix rows and columns.
6. Listing of program and data files:

PROGRAM FILE: LOOKAT2

30/01/25. 09.00.07.
PROGRAM LOOKAT2

```
00100 PROGRAM LOOKAT(INPUT,OUTPUT,TAPE1,TAPE2,TAPE3)
00101C
00102C THIS PROGRAM READS A WATER TAPE (TAPE1) AND DEPENDING ON FORMAT 99
00103C SCANS THE ORIGIN OR DESTINATION BEA-PE PAIRS FOR UNIQUE VALUES.
00104C THOSE UNIQUE VALUES ARE STORED IN ARRAYS BEA/PE AND THEN WRITTEN
00105C OUT TO TAPE2 IN A SORTABLE FORM. THIS FORM IS INPUT TO TABLED
00106C SO THAT THE TABLE CAN BE CUSTOM TAILORED FOR EACH YEAR RUN BECAUSE
00107C THE ARRAYS ARE SO LARGE.
00110 IMPLICIT INTEGER(A-Z)
00120 DIMENSION BEA(177),PE(17701)
00130 REWIND 1
00140 REWIND 2
00145 WRITE(2,999)
146 999 FORMAT(" AB TOT000")
00150 COUNT = 0
152 LINESOT=1
00160 100 READ(1,99)INBEA,INPE
00170 IF(EOF(1)) 9999,110
00180 110 CONTINUE
182 IF(INBEA.EQ.915)INBEA=15
00185 COUNT = COUNT + 1
00190 INBEA = INBEA + 1
00200 IF(INBEA.GE.1.AND.INBEA.LE.177)GO TO 120
205 INBEAX=INBEA-1
00210 WRITE(3,*)"OVFLD INBEA = ",INBEAX," INPE = ",INPE," LINE = ",COUNT
00220 GO TO 100
00230 120 CONTINUE
00240 IF(BEA(INBEA).EQ.0)GO TO 140
00250 INDEX1 = (INBEA-1)*100 + 1
00260 INDEX2 = INDEX1 + BEA(INBEA) - 1
00270 DO 130 I=INDEX1,INDEX2
00280 IF(PE(I).EQ.INPE)GO TO 100
00290 130 CONTINUE
00310 BEA(INBEA) = BEA(INBEA) + 1
00320 IF(BEA(INBEA).GT.100)GO TO 9998
00330 PE(INDEX2+1) = INPE
00340 GO TO 100
```

LOOKAT2 (Continued)

```
00340 140 CONTINUE
00350 BEA(INBEA) = 1
00360 INDEX1 = (INBEA-1)*100 + 1
00370 PE(INDEX1) = INPE
00380 GO TO 100
00390 9998 CONTINUE
00400 WRITE(3,*) "OVFLD IN ARRAY.BEA = ", INBEA, " ,LINE= ", COUNT
00410 9999 DO 10000 I=1,177
00420 IF(BEA(I).EQ.0) GO TO 10000
00430 WRITE(2,98) I,1,I-1
432 LINESDT=LINESDT+1
00450 INDEX1 = (I-1)*100 + 1
00460 INDEX2 = INDEX1 + BEA(I) - 1
00470 DO 9000 J=INDEX1,INDEX2
00480 WRITE(2,97) I,2,PE(J)
482 LINESDT=LINESDT+1
00490 9000 CONTINUE
00500 10000 CONTINUE
505 WRITE(2,998) LINESDT
00510 REWIND 1
00520 REWIND 2
526 WRITE(3,96) LINESDT
527 96 FORMAT("ROWS=",I3)
528 998 FORMAT(" AA      ",I4," LINES")
00530 STOP
535 99 FORMAT(I3,I4)
00540 98 FORMAT(I3,I3,1X,*,BEA*,I3,3)
00550 97 FORMAT(I3,I3,7X,*,PE*,I4,4)
00560 1 END
```

Input File

Tape 1 = DATA

0471320047132010	1428	1000	981	1254	1459	1900	2260
0471330048135510	1934	1000	981	1253	1460	1614	1729
0471330049132010	553	0	0	0	0	1000	1857
0481320049132010	264	1000	1246	2129	2913	3144	3534
0481335048135510	76	1000	867	523	74	0	0
0481335048135510	262	1000	867	523	74	0	0
0481355114011010	9	1000	1000	4000	7190	17667	17571
0481355114030210	12	1000	1000	4000	7190	17667	17571
0481355143274010	63	1000	984	3873	7143	10190	14127
0481360048135510	284	1000	867	523	74	0	0
0501400048135510	385	1000	1166	2265	3291	5706	7813
0501400066061010	19	0	1000	0	0	0	0
0540234138040510	5	1000	1150	1450	1750	2950	4100
0540234138041010	15	1000	1150	1450	1750	2950	4100
0620238138040510	172	1000	1123	1443	1719	2552	3227
0620238138041010	31	1000	1123	1443	1719	2552	3227
1070238138041010	27	1000	0	0	0	0	0
1150204046048510	28	1000	1139	1667	2083	2611	2917
1150204048135510	50	0	0	1000	2453	4219	4609
1150204066070010	16	0	1000	0	0	0	0
1150206046048510	8	1000	1139	1667	2083	2611	2917
1150206043135510	14	0	0	1000	2453	4219	4609
1171515055021610	3	1000	0	1000	1333	2000	2667
1171520066070010	14	1000	786	1571	1929	3286	4500
1352800066071510	12	1000	754	1579	1947	3263	4456
1352800066072510	45	1000	754	1579	1947	3263	4456
1380405062023810	6	1000	1167	1500	1667	2500	3167
1380415066061010	12	1000	583	1583	1917	3250	4417
0471320066027613	5	0	1000	6400	9400	16400	30800
0471320115130013	13	1000	769	0	0	0	0
0491305066028013	15	1000	1867	4267	5533	10467	16467
0491305139272513	71	1000	1296	2915	4803	9549	19704
0501370062023813	12	0	1000	1833	2917	6000	12000
0501370066027613	65	0	1000	1708	2400	4046	6846
0501370079032613	44	0	1000	1773	2545	4477	7864
0550220138040513	13	1000	1565	3674	5870	11761	23565
0550226138040513	26	1000	1565	3674	5870	11761	23565
0550226138270013	7	1000	1565	3674	5870	11761	23565
0660272066073013	70	1000	1074	1218	1471	2135	3086
0660276141275013	12	1000	1250	1250	1583	2500	3833
0660286052024213	7	1000	1143	1286	1429	1857	2714
0660286062023613	31	1000	1226	2871	3871	6645	11258
0660725066027213	50	1000	1074	1218	1471	2135	3086
0660730066027213	205	1000	1074	1218	1471	2135	3086
0770002048134513	14	1000	1286	2143	2929	5143	9143
1140301048134513	12	1000	914	1439	1993	3532	6245
1140301052080513	10	1000	984	1333	1714	2619	4222
1140302048134513	127	1000	914	1439	1993	3532	6245
1140302052080513	53	1000	984	1333	1714	2619	4222
1140302055022013	27	1000	5222	7889	10704	18630	32556
1140302066027613	29	1000	2034	3207	4207	7103	12000
1150208066027613	14	1000	714	786	2214	6286	16286
1330450049130513	28	1000	1286	2143	3071	5607	10286
1380400066061013	7	1000	750	771	938	1458	2354
1380405048134513	49	1000	2429	4020	5551	9796	17306
1380405049130513	29	1000	966	2310	3138	5414	9172
1380405050137013	5	0	1000	1800	2800	4800	8400
1380405052025213	13	1000	2154	2846	3615	5538	8923
1380405062023813	11	1000	1364	455	636	1273	2545
1380405066061013	11	1000	750	771	938	1458	2354
1380405066070013	30	1000	750	771	938	1458	2354
1392725049130513	531	1000	1305	2149	3055	5623	10356
1392725066028013	12	1000	83	1500	1583	1667	417
1412730055022013	35	1000	1229	1914	2543	4371	7457
1412730066027413	12	1000	1167	1500	2000	3250	5375
1412750066070013	12	1000	1167	1500	2000	3250	5375
1422735055022213	93	1000	129	194	258	452	785
1432740062023813	121	1000	1240	1810	2446	4289	7521
1432740066070013	132	1000	1115	1596	2058	3333	5397
1432740066070513	24	1000	1115	1596	2058	3333	5397

Output File

Tape 2 = ORIGIN

58 LINES

TOT000

BEA047

PE1320

PE1330

BEA048

PE1320

PE1335

PE1355

PE1360

BEA049

PE1305

BEA050

PE1370

PE1400

BEA054

PE0234

BEA055

PE0220

PE0226

BEA062

PE0238

BEA066

PE0272

PE0276

PE0286

PE0725

PE0730

BEA077

PE0002

BEA107

PE0238

BEA114

PE0301

PE0302

BEA115

PE0204

PE0206

PE0208

BEA117

PE1515

PE1520

BEA133

PE0450

BEA135

PE2800

BEA138

PE0400

PE0405

PE0415

BEA139

PE2725

BEA141

PE2730

PE2750

BEA142

PE2735

BEA143

PE2740

BEST DOCUMENT AVAILABLE

D-5. ORBRUN

1. Purpose: Used to generate the procedure call statement needed to execute TBQCMPL.
2. Name of the permanent binary object file: ORBFINB.
3. Associated procedure file: RUNLKZ
4. Input files:

TAPE3: a file generated from LOOKAT2 and containing the count of the number of matrix rows and columns.

TAPE4:(RUNOUT):a file containing the procedure call statement needed to execute TBQCMPL.

BEST DOCUMENT AVAILABLE

OUTPUT FILE

TAPE = RUNOUT

CALL, TBQCMPL(ROWS=200,COLS=300)

PROGRAM FILE: ORBRUN

30/01/25. 09.01.45.
PROGRAM ORBRUN

```
00100 PROGRAM ORBRUN(INPUT,OUTPUT,TAPE3,TAPE4)
00110 READ(3,100)LINE1,LINE2
00120 WRITE(4,101) LINE1,LINE2
00130 REWIND 3
00140 REWIND 4
00150 STOP
00160 100 FORMAT(A8/A8)
170 101 FORMAT("CALL.TBQCML(",A8,"",",",A8,
00180 END
```

D-6. ORBYRPG

1. Purpose: Used to generate a file containing the PE flows for any year between 1976 and 2040.
2. Name of the permanent binary object file: ORBYRB.
3. Associated procedure file: ORBTBQ.
4. Input files:
 - TAPE2(DATA): the file containing the PE growth index records.
5. Output files:
 - TAPE1: contains the PE flows for the selected year as the file serves only as an intermediate file it is not saved.
6. Listing of program:

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PROGRAM FILE: ORBYRPG

```
/LNH,F=ORBYRPG
00100 PROGRAM ORBYRPG (INPUT,OUTPUT,TAPE1,TAPE2)
00110 DIMENSION JYEAR(6),INDEX(6)
00120+, IEM(5)
00130 DATA JYEAR/1976,1980,1990,2000,2020,2040/
00140 REWIND 1
00150 REWIND 2
00160 1 READ(2,101) IYEAR
00170 DO 10 J=1,6
00180 IF (JYEAR(J).LE.IYEAR) GOTO 10
00190 J1=J-1
00200 J2=J
00210 IF (JYEAR(J1).EQ.IYEAR) J2=J1
00220 GOTO 20
00230 10 CONTINUE
00240 J1=6
00250 J2=6
00260 20 IF (J1.NE.J2) PCT=1000*(IYEAR-JYEAR(J1))/(JYEAR(J2)-JYEAR(J1))
00270 PCT=PCT/1000.
00280 25 READ(2,102) IBEA,IPE,JBEA,JPE,JCOM,VAL,(INDEX(K),K=1,6)
00290 IF (EOF(2)) 90,28
00300 28 CONTINUE
00310 30 JINDEX=PCT*(INDEX(J2)-INDEX(J1))+.5
00320 JVAL=VAL*(INDEX(J1)+JINDEX)/1000.+.5
00330 IF (JVAL.EQ.0) GOTO 25
00340 27 WRITE(1,103) IYEAR,IBEA,IPE,JBEA,JPE,JVAL,JCOM
00350 GOTO 25
00360 90 CONTINUE
00370 REWIND 1
00380 REWIND 2
00390 101 FORMAT(I4 )
00400 STOP
00410 102 FORMAT(2(A3,A4),A2,F7.0,6I7)
00420 103 FORMAT(I4,2(A3,A4),I10,A2)
00430 END
EOI ENCOUNTERED.
```

D-7. TABLEQ2

1. Purpose: Used to generate a hard-copy of the commodity OD BEA-PE matrices.
2. Name of the permanent binary object file: TABLEQB.
3. Associated procedure file: ORBTBQ.
4. Input files:
 - TAPE1: the file produced from ORBYRPG containing the PE flows for the selected year;
 - TAPE4(ORIGIN): the file containing the set of matrix row BEA-PEs.
 - TAPE5(DESTIN): the file containing the set of matrix column BEA-PEs.
5. Output files:
 - TAPE2(ORBOUT): contains the hard-copy print-out of the commodity matrices.
6. Listing of program and data files:

BEST DOCUMENT AVAILABLE

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PROGRAM FILE: TABLEQ2

```

PROGRAM TABLEQ2(OUTPUT,TAPE1,TAPE2,TAPE3=OUTPUT,TAPE4,TAPES)
IMPLICIT INTEGER(A-Z)
LOGICAL FIRSTRD,GRANDT
COMMON/AAA/DATARRAY(*NROW,*NCOL),ROWTITL(*NROW),COLTITL(*NCOL)
COMMON/RHB/YEAR,LGPOUP
COMMON/CCC/GRANDT
DATA NUMROWS/*NROW/,NUMCOLS/*NCOL/
DATA INCOUNT/0/,ROWTITL(1)/10HGRAND TOTL/

C
C IF WORD 57 IS NOT 0 PERFORM GRAND TOTAL SCAN.
C
GRANDT = .FALSE.
IF(MEMGET(57).NE.0)GRANDT = .TRUE.

C
FIRSTRD=.TRUE.
TOTWRDS=NUMROWS * NUMCOLS
CALL MEMSET(0,DATARRAY,TOTWRDS)
CALL MEMSET(0,ROWTITL,NUMROWS)
CALL MEMSET(0,COLTITL,NUMCOLS)

**
** READ THROUGH ROW HEADING FILE AND FILL ROWTITL
** (BEAS ARE STORED AS NEGATIVE IN ORDER TO DISTINGUISH)
HEAD(4,*)HEADREC
9301 FORMAT(16X,I3)
IF(EOF(4))301,302
301 PRINT*,"EMPTY ROW FILE"
GO TO 130
302 CONTINUE
IF(HEADREC.NE.NUMROWS)PRINT *,"WARNING...ROW COUNT ERROR"
DO 3333 I=1,NUMROWS
HEAD(4,9302)LAH1,NUM1,NUM2
9302 FORMAT(A3,I3,2X,I4)
IF(LAH1.EQ.3HBEA)303,304
303 ROWTITL(I)=0-NUM1
GO TO 3333
304 ROWTITL(I)=NUM2
3333 CONTINUE

**
** READ THROUGH COLUMN HEADING FILE AND FILL COLTITL
** (BEAS ARE STORED AS NEGATIVE IN ORDER TO DISTINGUISH)
HEAD(5,*)HEADREC
IF(EOF(5))401,402
401 PRINT*,"EMPTY COLUMN FILE"
GO TO 130
402 CONTINUE
IF(HEADREC.NE.NUMCOLS)PRINT *,"WARNING...COLUMN COUNT ERROR"
DO 1111 J=1,NUMCOLS
HEAD(5,4402) LAH1,NUM1,LAH2,NUM2
9402 FORMAT(A3,I3,A2,I4)
IF(LAH1.EQ.3HBEA)403,404
403 COLTITL(J)=0-NUM1
GO TO 1111
404 COLTITL(J)=NUM2
1111 CONTINUE

**
** ---BEGIN PROCESSING WATER FILE---
** READ THROUGH FILE 1
**
10 HEAD(1,9010) YEAR,BEAO,PEO,BEAD,PEO,TONS,GROUP
9010 FORMAT(I4,I3,I4,I3,I4,I10,I2)
IF(EOF(1))20,50
20 IF(FIRSTRD)30,40
30 PRINT*,"EMPTY FILE"

```


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```

PRINT*,"JOB ABORTED"
GO TO 130
40 CALL PRINTIT
GO TO 130
50 INCOUNT=INCOUNT+1
IF(READ.LT.1.OR.BEAD.GT.175)GO TO 10
IF(READ.LT.1.OR.BEAD.GT.175)GO TO 10
IF(FIRSTRD)60,70

**
** IF IT IS THE FIRST TIME THRU. INITIALIZE AND PROCESS
** AS A NEW BEA ORIGIN
**
60 PRINT*," FIRST READ = ",BEAD,PEO,BEAD,PEO
CALL FINDROW(BEAD,PEO,BEAROW,NUMBERW)
CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
FIRSTRD=.FALSE.
GO TO 120

**
** COMPARE THIS RECORD TO LAST RECORD
**
** IF NEW GROUP, PRINT LAST GROUP AND RESTART
**
70 IF(GRANDT)GO TO 75
IF(GROUP.EQ.LGROUP) GO TO 80
CALL PRINTIT
TOTWRDS=NUMROWS * NUMCOLS
CALL MEMSET(0,DATARAY,TOTWRDS)
75 CALL FINDROW(BEAD,PEO,BEAROW,NUMBERW)
CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
GO TO 120

**
** IF NEW BEA ORIGIN, RECALCULATE BOTH SUBSCRIPTS
**
80 IF(READ.EQ.LBEAD) GO TO 100
CALL FINDROW(BEAD,PEO,BEAROW,NUMBERW)
83 CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
GO TO 120

**
** IF NEW PE ORIGIN, RECALCULATE BOTH SUBSCRIPTS
**
100 IF(PEO.EQ.LPEO) GO TO 105
CALL FINDROW(BEAD,PEO,BEAROW,NUMBERW)
101 CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
GO TO 120

**
** IF NEW BEA DESTINATION, RECALCULATE COLUMN SUBSCRIPTS ONLY
**
105 IF(BEAD.EQ.LBEAD) GO TO 110
CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
GO TO 120

**
** IF NEW BEA DESTINATION, RECALCULATE COLUMN SUBSCRIPTS ONLY
**
110 IF(PEO.EQ.LPEO) GO TO 120
CALL FINDCOL(BEAD,PEO,BEACOL,NUMPECL)
GO TO 120

** IF THIS RECORD=LAST, ADD TOTALS WHERE YOU ARE
** WITHOUT RECALCULATING SUBSCRIPTS
**
120 PEROW=BEAROW+NUMBERW
PECOL=BEACOL+NUMPECL
IF(BEAROW.GT.NUMROWS.OR.PEROW.GT.NUMROWS)GO TO 9800
IF(BEACOL.GT.NUMCOLS.OR.PECOL.GT.NUMCOLS)GO TO 9900

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DATARAY(1,1)=DATARAY(1,1)+TONS
DATARAY(1,BEACOL)=DATARAY(1,BEACOL)+TONS
DATARAY(HEAROW,1)=DATARAY(HEAROW,1)+TONS
DATARAY(HEAROW,HEACOL)=DATARAY(HEAROW,HEACOL)+TONS
DATARAY(1,PECOL)=DATARAY(1,PECOL)+TONS
DATARAY(PEROW,1)=DATARAY(PEROW,1)+TONS
DATARAY(PEROW,PECOL)=DATARAY(PEROW,PECOL)+TONS
DATARAY(PEROW,HEACOL)=DATARAY(PEROW,HEACOL)+TONS
DATARAY(HEAROW,PECOL)=DATARAY(HEAROW,PECOL)+TONS
LBEAO=HEAO
LHEAD=HEAD
LPEO=PEO
LPED=PED
LGROUP=GROUP
GO TO 10
130 WRITE(3,4130) INCOUNT
4130 FORMAT(1H0,5X,"RECORDS READ = ",I5)
STOP
4800 PRINT *, " ERROR...ERROR...ERROR..."
PRINT *, " HEAROW OR PE ROW EXCEEDED ARRAY BOUNDS"
PRINT *, " HEAROW = ",HEAROW," AND PEROW = ",PEROW
PRINT *, " MAX VALUE IS ",NUMROWS
STOP
4900 PRINT *, " ERROR...ERROR...ERROR..."
PRINT *, " BEACOL OR PECOL EXCEEDED ARRAY BOUNDS"
PRINT *, " BEACOL = ",BEACOL," AND PECOL = ",PECOL
PRINT *, " MAX VALUE IS ",NUMCOLS
STOP
END
SUBROUTINE FINDROW(BEA,PE,HEAROW,NUMPE)
** FIND WHICH ROW OF THE ARRAY TO PUT A PARTICULAR PE WITHIN BE.
** THE VALUES OF BEA AND PE ORIGINS ARE PASSED IN, AND THE BEA ROW SUBSCRIPT
** AND THE INCREMENT (NUMPE) USED TO CALCULATE PE ROW SUBSCRIPT ARE RETURNED.
**
IMPLICIT INTEGER(A-Z)
COMMON/AAA/DATARAY(*NROW,*NCOL),ROWTITL(*NROW),COLTITL(*NCOL)
DATA NUMROWS/*NROW/
BEA=0-BEA
DO 200 I=1,NUMROWS
IF(ROWTITL(I).EQ.BEA)10,200
10 BEAROW=K=I
15 K=K+1
IF((K.GT.NUMROWS).OR.(ROWTITL(K).LT.0))20,30
20 PRINT*,"PE NO.",PE,"IN BEA ",BEA," NOT FOUND ON ROW FILE"
DO 25 K=1,NUMROWS
25 PRINT *, " ROWTITL(",K,") = ",ROWTITL(K)
STOP
30 IF(ROWTITL(K).EQ.PE)40,15
40 NUMPE=K-BEAROW
BEA=0-BEA
RETURN
200 CONTINUE
END
SUBROUTINE FINDCOL(BEA,PE,BEACOL,NUMPE)
**
** FIND WHICH COLUMN OF THE ARRAY TO PUT A PARTICULAR PE WITHIN BE.
** THE VALUES OF BEA AND PE ARE PASSED IN, AND THE BEA COLUMN SUBSCRIPT
** AND THE INCREMENT (NUMPE) USED TO CALCULATE PE COLUMN SUBSCRIPT ARE
** RETURNED.
IMPLICIT INTEGER(A-Z)
COMMON/AAA/DATARAY(*NROW,*NCOL),ROWTITL(*NROW),COLTITL(*NCOL)
DATA NUMCOLS/*NCOL/
BEA=0-BEA

```

(4)

```

DO 200 I=1,NUMCOLS
  IF (COLTITL(I).EQ.BEA) 10,200
10 BEACOL=K=I
15 K=K+1
  IF ((K.GT.NUMCOLS).OR.(COLTITL(K).LT.0)) 20,30
20 PRINT*, "PE NO.",PE, "IN BEA ",BEA, "NOT FOUND ON COL FILE"
  DO 25 K=1,NUMCOLS
25 PRINT *, " COLTITL(",K,") = ",COLTITL(K)
  STOP
30 IF (COLTITL(K).EQ.PE) 40,15
40 NUMPE=K-BEACOL
  BEA=0-BEA
  RETURN
200 CONTINUE
END
SUBROUTINE PRINTIT
  IMPLICIT INTEGER(A-Z)
  COMMON/AAA/DATARRAY(*NROW,*NCOL),ROWTITL(*NROW),COLTITL(*NCOL)
  COMMON/HBB/YEAR,LGROUP
  DIMENSION LINE(16)
  LOGICAL NEWGRUP
  DATA NUMROWS/*NROW/
  DATA NUMCOLS/*NCOL/
  NEWGRUP=.TRUE.
  IF (DATARRAY(1,1).EQ.0) RETURN

```

```

**
** FIND START AND END SUBSCRIPT OF SET CONTAINING 16 NON-ZERO
** COLUMN TOTALS
**

```

```

END=0
100 START=END+1
  IF (START.GT.NUMCOLS) RETURN
  END=START+15
  J=START
  COUNT = 0
110 IF (DATARRAY(1,J).EQ.0) END=END+1
  IF (J.LE.NUMCOLS.AND.DATARRAY(1,J).NE.0) COUNT=COUNT+1
  J=J+1
  IF (J.LE.END) GO TO 110
  IF (COUNT.LT.1) RETURN
  IF (END.GT.NUMCOLS) END=NUMCOLS
  CALL HEADER(START,END,NEWGRUP)
  DO 500 I=1,NUMROWS
  IF (DATARRAY(I,1).EQ.0) GO TO 500
  COUNT=1
  DO 120 J=START,END
  IF (DATARRAY(I,J).EQ.0) GO TO 120
  LINE(COUNT)=DATARRAY(I,J)
  COUNT=COUNT+1
120 CONTINUE
  COUNT=COUNT-1
  IF (COUNT.LT.1) RETURN
  IF (ROWTITL(I)) 130,140,150
130 BEANUM=IABS(ROWTITL(I))
  CNT2=COUNT-1
  IF (COUNT.GT.1) GO TO 135
  WRITE(2,9125) BEANUM,LINE(1)
  GO TO 500
135 WRITE(2,9125) BEANUM,LINE(1),CNT2,(LINE(K1),K1=2,COUNT)
9125 FORMAT(/,1X,4HBEA ,I3,6X,I10,=(I7))
  GO TO 500
140 CONTINUE
  CNT2=COUNT-1

```

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BEST DOCUMENT AVAILABLE

```

IF (COUNT.GE.2) GO TO 145
WRITE(2,9135)LINE(1)
GO TO 500
145 WRITE(2,9135)LINE(1),CNT2,(LINE(K1),K1=2,COUNT)
9135 FORMAT(/,1X,*TOTAL*,8X,I10,=(I7))
GO TO 500
150 CNT2=COUNT-1
IF (COUNT.GE.2) GO TO 155
WRITE(2,9130)HWTITL(1),LINE(1)
GO TO 500
155 WRITE(2,9130)HWTITL(1),LINE(1),CNT2,(LINE(K1),K1=2,COUNT)
9130 FORMAT(3X,3HPE ,14,4X,I10,=(I7))
500 CONTINUE
GO TO 100
END
SUBROUTINE HEADER(START,END,NEWGRP)
IMPLICIT INTEGER(A-Z)
COMMON/AAA/DATARAY(*NROW,*NCOL),ROWTITL(*NROW),COLTITL(*NCOL)
COMMON/BBB/YEAR,LGROUP
COMMON/CCC/GRANDT
DIMENSION HEADR(2,16),CGN(45)
LOGICAL NEWGRP,GRANDT
DATA CGN/"COAL AND C","OKE"," ","PETROLEUM ","FUELS"," ",
+ "CRUDE PETRU","OLEUM"," ","AGGREGATES"," "," " "GMAINS"," "," ",
+ "CHEMICALS ","AND FERTIL","IZENS","URES AND M","INERALS"," ",
+ "IRON ORE; ","STEEL AND ","IRON","FEED AND F","OOD PRODUC",
+ "TS, NEC","WOOD AND P","APER PRODUC","CTS","PETROLEUM ",
+ "PRODUCTS, ","NEC","NONMETALLI","C MINERAL ","PRODS, NEC",
+ "NONFERROUS"," METALS AN","D ALLOYS","MANUFACTUR","ED PRODUCT",
+ "S, NEC","OTHERS, NE","C"," " /
N3=LGROUP*3
N1=N3 - 2

```

C IF GRAND TOTAL..USE FORMAT 9005. ELSE USE 9010.

```

C
IF (.NOT.GRANDT)GO TO 10
WRITE(2,9005)YEAR
9005 FORMAT(1H1,/,26X,"TABLE . OHIO RIVER SYSTEM: WATERHORNE ",
+ "COMMERCE BY REA AND PE",/,52X,"COMMODITY TOTAL ",/,
+ 57(1H ),"YEAR ",I4,/,53(1H ),"(HUNDREDS OF TONS)",/,
+ 1X,14(1H-),12X,103(1H-),/
+ " ORIGINS",48X,"DESTINATIONS",/,1X,14(1H-),12X,103(1H-),/)
GO TO 15

```

```

C
10 WRITE(2,9010)LGROUP,(CGN(N),N=N1,N3),YEAR
9010 FORMAT(1H1,/,26X,"TABLE . OHIO RIVER SYSTEM: WATERHORNE ",
+ "COMMERCE BY REA AND PE",/,51X,"COMMODITY GROUP ".12,"": ".3410,/,
+ 57(1H ),"YEAR ",I4,/,53(1H ),"(HUNDREDS OF TONS)",/,
+ 1X,14(1H-),12X,103(1H-),/
+ 8H ORIGINS,48(1H ),"DESTINATIONS",/,1X,14(1H-),12X,103(1H-),/)
15 COUNT=1
DO 100 J=START,END
IF (DATARAY(1,J).EQ.0) GO TO 100
IF (COLTITL(J))20,30,40
20 HEADR(1,COUNT)=7H *HEA*
HEADR(2,COUNT)=IABS(COLTITL(J))
GO TO 50
30 CONTINUE
HEADR(1,COUNT) = 7H TOTAL
HEADR(2,COUNT) = 0
GO TO 50
40 HEADR(1,COUNT)=7H PE
HEADR(2,COUNT)=COLTITL(J)

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```

50 CONTINUE
   COUNT=COUNT+1
100 CONTINUE
   COUNT=COUNT-1
   IF(COUNT.LT.1) RETURN
*
   IF(STANT.EQ.1)GO TO 60
C
C  OUTPUT NORMAL LINE
C
   WRITE(2,99)COUNT,(HEADR(1,K),K=1,COUNT)
   WRITE(2,98)COUNT,(HEADR(2,K),K=1,COUNT)
99 FORMAT(17X,=A7)
98 FORMAT(17X,=I7)
   RETURN
60 CONTINUE
C
C  OUTPUT LINE WITH WIDE FIRST FIELD
C
   WRITE(2,97)HEADR(1,1)+COUNT-1,(HEADR(1,K),K=2,COUNT)
   WRITE(2,96)COUNT-1,(HEADR(2,K),K=2,COUNT)
97 FORMAT(14X,A10,=A7)
96 FORMAT(14X,10X,=I7)
   RETURN
   END

```